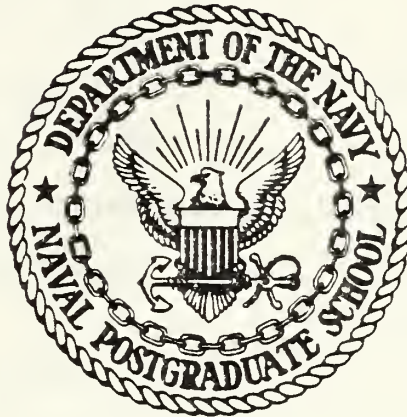


A VESSEL INSPECTION INFORMATION SYSTEM

Larry Mark Wilson

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

A VESSEL INSPECTION INFORMATION SYSTEM

by

Larry Mark Wilson

September 1977

Thesis Advisor:

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by

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Lieutenant, United States Coast Guard
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requirements for the degree of

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ABSTRACT

Marine safety is a major responsibility of the United States Coast Guard. In carrying out this task, the Coast Guard conducts periodic inspections of existing merchant vessels and supervises construction of new vessels. To support and help promote marine safety, a Vessel Inspection Information System (VIIS) has been proposed. The system would be used to capture design information, inspection data, and other relevant information; store it in a centralized data base; and make the information available to Coast Guard Units as needed through the use of interactive computer terminals. The purpose of this thesis is to present the results of a computer program which provides cost estimates of the communications networks in VIIS and provides information on network performance.

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I. INTRODUCTION

Merchant Marine Safety is one of the primary missions of the United States Coast Guard. The merchant marine safety function was developed in the Coast Guard in 1942 when it was transferred from the former Bureau of Marine Inspection and Navigation of the Department of Commerce [1]. This thesis traces the development of the Merchant Marine Safety Function in the Coast Guard, describes a proposed Vessel Inspection Information System for improving the Coast Guard's efficiency in this field, and provides a model for evaluating costs and performance of the proposed system.

A. HISTORY OF UNITED STATES MERCHANT MARINE SAFETY

Some events of historical significance which contributed to the development of merchant marine safety follow.

1807 Robert Fulton's development of the steamboat CLERMONT was followed by the use of numerous river steamboats [1, 2].

1819 The SAVANNAH became the first American steamboat to cross the Atlantic Ocean [1].

1824 Due to increasing numbers of lives lost in steamboat boiler explosions, Congress directed the Secretary of the Treasury to conduct investigations to determine their causes [2].

1838 The first actual recognition of federal responsibility in the marine safety field was contained in Congressional legislation looking to better security of the lives of passengers embarked on steam-propelled vessels. Certificated inspections of hulls and boilers were required, as well as an adequate number of experienced engineers and provision of lifeboats, signal lights, and firefighting equipment [1, 2].

1852 The Steamboat Inspection Service was formed in the Treasury Department as part of the "Steamboat Act". This act required that inspectors be paid fixed salaries from the Treasury Department in lieu of the fees they had previously received from the vessel owners and masters. The act also provided for the licensing of all engineers and pilots of passenger-carrying steam vessels and required permits for carrying certain dangerous or inflammable cargoes [2].

1871 Administration of inspection laws was reorganized under the office of "Supervising Inspector General" by an act of Congress. The act also required all steam vessels except public and foreign vessels to be inspected and their masters, chief mates, engineers, and pilots to be licensed. A significant aspect of the act was that it was directed toward the promotion of safety of all persons, passengers and crew, on board steam vessels [1].

1897 It was recognized that the internal-combustion engine had become a major means of large vessel propulsion. Inspection laws were extended to cover all mechanically propelled vessels of more than 15 tons carrying passengers and freight for hire [2].

1903 The Department of Commerce and Labor was formed. The Steamboat Inspection Service and all duties, powers,

authority and jurisdiction related to shipping were transferred from the Secretary of the Treasury to the new Secretary of Commerce and Labor [1].

1904 Inspection laws were strengthened and the authority of inspectors was markedly increased after the GENERAL SLOCUM fire which took 955 lives. The responsibility for the tragedy was placed largely upon the officers of the Steamboat Inspection Service for failing to carry out their duties [2].

1910 The "Motorboat Act" extended inspection laws to boats under 65 feet in length propelled by machinery. Safety regulations relating to equipment were established. The "Wireless-Ship Act" required certain ocean steamers to be equipped with operators and apparatus for radio communications before leaving any United States port [1, 2].

1913 The Department of Labor was organized. Those functions related to merchant marine safety remained with the Department of Commerce [1].

1915 The "Seaman's Act" granted local inspectors the authority to issue certificates to able seamen and lifeboatmen after examination. It provided for the supervision of payment of seamen's wages and included provisions as to required lifesaving equipment for the crew [2].

1932 As part of the "Economy Act" during the depression, the Bureau of Navigation and the Steamboat Inspection Service were merged into the Bureau of Navigation and Steamboat Inspection [1, 2].

1934 The MORRO CASTLE disaster resulted in the death of 134 persons. The MORRO CASTLE was constructed, equipped,

and fitted to meet all requirements of the Bureau of Navigation and Steamboat Inspection in effect at that time. A Congressional investigation revealed many weaknesses in the laws concerning maritime safety. Because of demands from the press, the public, and members of Congress itself, Congress took action and passed two important acts relating to maritime safety. The first act changed the name of the bureau to the Bureau of Marine Inspection and Navigation (BMIN), recognizing the fact that with new types of power available, "steamboat" was no longer appropriate. It provided for the establishment of Marine Casualty Inspection Boards whose jurisdiction covered all marine casualties, not just those involving licensed personnel. Finally, it provided for the establishment of a technical division and required that all plans and design specifications for United States passenger vessels of 100 gross tons and over, propelled by machinery, must be approved by the Director of BMIN with the advice of this technical staff. The second act known as the "Merchant Marine Act of 1936" provided for qualifications, examinations, and issuance of certificates of service to unlicensed personnel, and the issuance of continuous discharge books to all seagoing personnel [2].

1940 The "Motorboat Act of 1940" was the first federal attempt to regulate the operation of motorboats from the safety standpoint. This act required a minimum of safety equipment to be aboard, such as proper navigational lights, fog signal devices, fire extinguishers, and life preservers. It did not, however, provide for an inspection of the boat itself for safety nor did it establish standards for operators [2].

1942 The functions of the BMIN related, directly or indirectly, to safety at sea were transferred to the United States Coast Guard by Executive Order. Thus the Coast Guard became the sole federal agency charged with the

responsibility for safety at sea. A Merchant Marine Council was established to study and recommend to the Commandant of the Coast Guard steps to improve the efficiency and welfare of American merchant seamen and to determine the effectiveness of safety equipment in use aboard ships [1, 2].

1956 Inspection laws were extended to cover passenger-carrying vessels of not more than 65 feet in length and under 100 gross tons, carrying more than six passengers [1].

1959 Several old inspection laws containing detailed requirements on lifesaving equipment, firefighting and other safety equipment were repealed and authorization was granted to the Commandant of the Coast Guard to promulgate regulations covering these items thereby making it possible to adjust to changing technology [1].

1977 In the past decade and a half, significant additions in maritime safety laws and regulations have occurred, pertaining to special vessel classes, due to changing technologies and ship designs. These include but are not limited to nuclear powered ships, containerized cargo vessels, super tankers, and liquefied natural gas (LNG) transports now under construction. After several major disasters in the 1976-1977 winter season involving foreign tankers, foreign tank vessels are now required to pass U. S. inspections prior to entering a U.S. port.

B. CURRENT MERCHANT MARINE SAFETY FUNCTIONS OF THE COAST GUARD

The Coast Guard is charged with the responsibility of the inspection and regulation of vessels and equipment for the protection of passengers, crew, and cargo. They must carry out periodic inspections of merchant vessels and enforce regulations pertaining to lifesaving, firefighting, and other safety equipment in determining the seaworthiness of the vessel prior to issuing a certificate of inspection. To fulfill this obligation, factory inspections of certain equipment and materials for use in merchant vessels are made; navigational rules are developed and enforced; Federal regulations regarding vessel numbering are developed and enforced as well as the review of state motorboat regulation systems; and penalty procedures for violations of navigation and inspection laws are administered [1, 2, 3].

The Coast Guard is responsible for the regulation of marine personnel; which includes examining, licensing, and certifying them. They also prescribe vessel manning requirements for safe navigation; supervise shipment and discharge of merchant seamen; maintain merchant marine personnel records; and administer the security program as it relates to merchant seamen [1, 2].

In the engineering and technical fields, the Coast Guard approves plans and specifications for construction and alteration of merchant vessels; classifies vessels; conducts stability tests; and examines and tests equipment and devices submitted for approval or for determination of suitability. They also review vessel load-line certificates and enforce load-line regulations; and develop regulations

in the areas of naval architecture, marine, chemical, and electrical engineering, firefighting and other safety functions [1].

The Coast Guard investigates and reviews marine casualties and acts of incompetency or misconduct; licenses or certificates may be revoked or suspended as appropriate. They are also responsible for presenting these cases before the proper authorities as required [1].

Continuous liaison is maintained with maritime industry through the Merchant Marine Council. Maritime industry and other interested parties are kept informed of proposed regulations or changes to regulations through public hearings. Liaison is also maintained with the international maritime bodies through the International Co-ordinating Staff. They are responsible for presenting the position of the United States regarding international maritime issues [1].

Collection of data, formulation of reports, and transmission of information pertaining to the duties and responsibilities listed above involves a significant amount of manpower and effort on the part of the Coast Guard. Problems exist in several areas, and particularly those related to transmission of information. The Coast Guard has an obligation to schedule vessel inspections, whenever possible, to coincide with a vessel's operating schedule [1]. Requiring a vessel to remain in port for routine inspections costs the ship's owners thousands of dollars per day; it is most desirable to hold inspections when the vessel would normally be in port. In fulfilling this obligation to vessel owners and masters, problems develop in that today's higher speed vessels can travel between ports faster than their inspection records. An example of this problem is a ship travelling from its

homeport of Los Angeles to San Francisco, and requesting an inspection while in San Francisco, will probably arrive, have the inspection while cargo is being loaded or off-loaded, and depart before its inspection records have arrived from Los Angeles. The San Francisco inspector is at a disadvantage in conducting his inspection since he does not have a list of previous discrepancies or problem areas that were observed during past inspections and required correction by the owners or master. The San Francisco inspector can get some information from the homeport over the phone, but the information is generally incomplete.

Transmission of information on merchant seamen is also a problem since they change vessels frequently and it takes time for the information to be updated. By the time files are updated, a seaman could have moved to another vessel.

To assist the Coast Guard in the merchant marine function, a Vessel Inspection Information System was suggested to provide real-time access to and updating of data at major ports throughout the United States. The system was to be used primarily in relation to the Coast Guard's merchant marine inspection function, with capabilities for expansion to include law enforcement and pollution investigation functions [4, 5].

Battelle Columbus Laboratories was contracted by the Coast Guard to develop a Vessel Inspection Information System.

II. VESSEL INSPECTION INFORMATION SYSTEM

The Vessel Inspection Information System (VIIS), as proposed, is a large-scale, comprehensive, computer-based information system to be utilized by Coast Guard personnel involved with the administration and execution of the Coast Guard's Merchant Vessel Safety Programs [4]. The system designs of VIIS are based on user needs as determined by interviews of potential users, and on availability of funds.

A. USER NEEDS

VIIS should be used as a tool for the capture, transmission, manipulation, and feedback of relevant information to support improvements in the vessel safety and inspection programs. VIIS must be able to maintain a comprehensive historical safety data base on each inspected vessel along with sufficient information on system capabilities to be useful in supporting the inspection function. The information about a vessel (its inspection requirements, safety requirements, and past inspection performance) must be readily available to Coast Guard Inspectors. Additionally, through the manipulation of data, VIIS should be capable of monitoring the status of a vessel with respect to periodic inspections, outstanding requirements, special examination requirements; provide administrative support in communicating with vessel owners with respect to the above requirements and with Coast Guard Headquarters with respect to required reports (periodic inspection letters and reports automatically prepared); and

provide management support in estimating future inspection requirements/workload implications for short-term planning and resource allocation [5].

B. PERFORMANCE CRITERIA

VIIS must be able to provide real-time "access to" and "updating of" vessel files. This requirement is readily apparent in cases of major marine casualties, disasters, and pollution incidents. Routine file maintenance and initial entry into the system will be accomplished with batch processing [5]. Even batch processing will provide a significant decrease in file updating time compared with today's paperwork system.

C. ALTERNATE SOLUTIONS

There were numerous options available in developing the VIIS system. The final proposals include five variations in the system. The differences are based on different funding levels and the Coast Guard's ability to extend services into the areas indicated.

1. Baseline System

The Baseline System was conservatively designed yet will be responsive to most user needs identified above. It is capable of capturing and recalling inspection histories, automatic safety and inspection status monitoring, outstanding requirements tracking, class defects detection, and communication of information among ports [4].

This system interfaces with Coast Guard inspection units only. The Baseline System would provide for coverage of the inspected fleet. This limitation requires that vessel information obtained through means other than the inspection function (casualty investigations, vessel characteristic updates, pollution incidents, etc.) must be transmitted to an inspection or a headquarters function to be entered into the system [4].

This network, as its name implies, is a "base system" upon which the following, larger systems could be built. In this regard, the Baseline System could be used as a test system to determine actual cost and performance data and compare this information with the predicted data prior to expanding to one of the larger systems.

2. All Merchant Marine System

This is an extension of the Baseline System to include the investigation and documentation functions. Coverage would include all inspected and documented vessels, and foreign vessels involved in casualties [4].

3. All Merchant Marine + Law Enforcement System

The All Merchant Marine System evolves into this system by including the Coast Guard's law enforcement functions; e.g., boarding and violation information [4].

4. Full System

With the addition of the Coast Guard's Environmental Protection Office as an on-line user, the Full System is

developed. Coverage is extended to include pollution incidents, and the investigation, reporting and analysis activities associated with them. The Full System provides coverage in virtually all areas of the Coast Guard's Merchant Vessel Safety Programs [4].

5. Ocean Ports System

The Ocean Ports System incorporates the same basic functions as the Baseline System but it is reduced in scope to provide coverage for large ocean-going vessels only; terminals are located at those ports where ocean-going vessels are inspected [4].

D. EQUIPMENT AND SPECIFICATIONS

1. Communication Lines

The communications network will be one of the following: (a) a network comprised of dedicated communications lines (General Services Administration(GSA) leased), dedicated lines shared with other Coast Guard activities (existing GSA leased), Federal Telecommunications System(FTS) lines and Direct Distance Dial(DDD) lines for low volume and non-CONTinental United States(CONUS) ports; (b) a network made up of all FTS lines used on a non-dedicated basis; (c) utilization of a network provided by a commercial time-sharing computer company [4, 5].

2. Communications Hardware

The communications hardware at each location is a function of the system being used and the type of lines available; e.g., New York. It is assigned a teleprinter in the Ocean Ports System, but CRT's in all other systems.

a. Modems

Modems are used to link the processing units and the terminals which are basically digital in nature with an analog telecommunications network [4, 6, 7, 8]. Several types of modems are used depending on the hardware at each terminal location. Asynchronous modems are used at ports using teleprinters while synchronous modems are utilized at ports having CRT's and/or high speed printers.

Asynchronous modems will be used to interface slow-speed teleprinters to the telephone network [4]. These modems allow the transmission of one character at a time as they are keyed at the terminal. The most common asynchronous modems available transmit at speeds up to 300 bits per second (approximately 30 characters per second if using an 8 bit ASCII code plus start and stop bits for each character). Asynchronous modems connected directly to a voice-grade telephone line use the entire bandwidth of the line, thereby eliminating the possibility of multiplexing signals [4, 6, 7].

Synchronous modems will be used to interface CRT terminals and high-speed printers to the communications network [4]. This type of modem allows information to be transmitted as blocks or strings of characters between buffered devices. As the transmission rate is not governed

by the typing rate at the terminal and start and stop bits are not required for each character, higher transmission rates are obtained [4, 6, 7]. 2400 bit per second modems (300 characters per second) will be used at CRT/Printer locations. In areas where VIIS lines are multiplexed into existing Coast Guard dedicated lines, 4800, 7200, or 9600 bit per second modems are used depending on anticipated traffic loads [4].

b. Modem Sharing Devices

Modem Sharing Devices (MSD) are used in conjunction with a modem to allow several terminals in the same vicinity to share a common modem [4]. In ports having a large volume of transactions and several terminals, MSD's will reduce the cost that would be incurred if each terminal had its own modem.

c. Alternate Dial-up Devices

Alternate Dial-up Devices (ADD) are introduced into the system to provide a backup capability for accessing VIIS via the FTS or DDD network in the event that service on the primary dedicated link is disrupted [4].

d. Data Access Arrangements

Data Access Arrangements (DAA) are inserted between user provided modems and the common carrier's network allegedly to prevent the network from being damaged by the alien equipment [4]. DAA's are not required for common carrier furnished modems or some user provided modems which meet required specifications.

e. Multiplexors

Multiplexors are used to consolidate several low-speed channels into a single line for long-distance transmissions. Multiplexors can significantly reduce communication line costs by decreasing the number of lines required [4, 6, 9].

Frequency Division Multiplexors(FDM) partition the voice grade communication link, having a bandwidth of 2700 cycles, into several sub-bands capable of supporting 150 bps or 300 bps transmission. In those locations where FDM's are used, modems are not required as the FDM performs that function. A disadvantage of FDM's is that only six 300 bps terminals can be multiplexed for a voice grade line. This problem can be reduced by splitting 300 bps channels into two 150 bps channels or by having more than one terminal share a channel and operate in a contention mode [4, 6, 9]. FDM's will be used where low transaction volume offices are spread over a large geographical area and can be linked with a single line.

Time Division Multiplexors(TDM) divide the voice grade channel into time slots, and each terminal is assigned to a given time slot. Time division multiplexing is basically a digital process; therefore, modems are required to interface the TDM with the communications network [4, 6, 8, 9]. TDM's will be used to multiplex both synchronous and asynchronous channels into a single synchronous channel for long-distance transmission.

f. User Terminal Devices

Six types of user terminal devices are utilized for communications with the host computer. The terminal devices located at each office depend upon the system being used and the volume of transactions at that location.

CRT Keyboard Displays with minimal capabilities of keyboard input and video display output will be required. The keyboard must include a full set of 64 upper-case ASCII characters, including a message control subset. The video display should have a minimum of 24 lines of 80 characters each. The CRT must be a buffered device capable of storing at least 1920 characters, should normally operate at a rate of 2400 bps, and should have an editing feature for character insertion, deletion and typeover [4].

Printers will be used in those offices with CRT's and high transaction volumes. Printers will be used to capture hardcopy output of information on the CRT video display that is necessary for permanent retention [4]. For those ports employing more than one CRT, a lesser number of printers might be required as not all information needs to be in hard-copy form. Printers should have a minimum of 64 upper-case ASCII characters, print at a rate of 150-300 characters per second, print six lines per inch, and have 80-132 characters per line. Where transaction volume does not warrant the use of a high-speed printer, slow-speed (30 characters per second) printers will be used. Slow-speed printers are used whenever possible due to their cost advantage.

Teleprinters are used for certain system configurations and in offices with low traffic volumes.

These devices will be used to communicate with the host computer asynchronously at 150 or 300 bps in ASCII code. These devices should be used primarily for data retrieval; data entry is feasible but inefficient due to the slower speeds and screen formats. Where teleprinters are used in conjunction with dedicated lines, teleprinters with integrated acoustic couplers will be used. The integrated acoustic coupler provides for alternate dial-up capabilities over the FTS or DDD networks in the event of disrupted service on the dedicated line [4].

Auxilliary Cassette Units will be used to permit "off-line" data entry operations in those networks using FTS or DDD lines (networks involving connect time charges) until sufficient data has been accumulated for continuous transmission to the host computer [4].

III. COMMUNICATIONS NETWORK; COST AND PERFORMANCE

The cost of setting up and maintaining the communications network for VIIS is a significant part of the systems total cost as is typical with any computer communications network. The Coast Guard required realistic cost estimates of the network prior to proceeding with any implementation options. The Coast Guard, as well as every other federal agency, is required to set minimum desired performance levels as well as keeping costs below established budget ceilings. Estimated cost and performance data become very important in deciding whether it is the right system at the right price and whether to proceed with or scrap the project.

To assist the Coast Guard in their decision-making process in regards to VIIS, a computer program was written to provide cost and performance estimates. The program is general and can provide cost and performance information for many computer communications networks with little or no modification required. The program was specifically written for use in a CP/CMS interactive mode, but the fortran program is also functional in a batch mode.

To provide cost and performance data, the program requires for each node in the network, the node name, the name of the predecessor node, the type of communication line between them, the line number, the distance between the two nodes or telephone company "V" and "H" coordinates for determining the distance, the expected number of characters transmitted to and from the node each month, and a codified list of communications equipment at the node. Where two or

more types of communications lines intersect at a node, individual data records are required for each line. Also required as inputs are the number of types of equipment available and the costs associated with each. The number of types of lines and their costs, whether it be by the hour or by the mile, are required. Finally, the number of characters per transaction broken down into the mean number of typed-in characters and the number of characters per frame, their standard deviations, the mean typing speed of the terminal user, estimated central processing unit (CPU) queueing and access times, and whether the lines will be operated in a full-duplex or half-duplex mode are required. (Frame is the name given to the display formats to be used in the system.)

The program uses the above inputs to determine the number of each type of equipment required for the network, the one-time and recurring equipment costs for each node, the cost of the communications line which links the node to the system, and the total number of connect hours for each node. The program also determines the equipment costs and communication line costs for each line in the network and for the network as a whole. Where distances were not included as input, the program computes the distances between nodes and provides a sum of the total number of the distances between nodes and provides the total number of miles of leased/dedicated lines and leased/shared lines. Also included as output is the total number of connect hours per month, a list of the independent lines in the network with the total number of characters per month on the line, the line number, the mean service time per transaction on the line, the mean number of transactions arriving for service each second, the overall utilization of the line, i.e., the fraction of time that the line is actually in use, the mean number of transactions waiting for service, the mean number of transactions in the network being served or

waiting to be served, the mean waiting time for service, and the total time in the system, being served and waiting to be served.

The program uses the following assumptions in arriving at the above output: if the distance is an input, the program assumes that it is correct and does not compute a distance for comparison; the program assumes that distances for FTS lines are not required and therefore not determined; that all CRT's operate at a data rate of 2400 bits per second and all teleprinters operate at a 300 bit per second rate; that the mean number of connect hours for each terminal is a function of the number of transactions per month, the mean number of characters per transaction, the mean typing rate of the user, the mean number of characters typed-in per transaction, the data rate, the idle time of the user at the terminal, and the CPU access and queueing times. The program assumes that the cost of any one piece of equipment or communication line is associated with one terminal only, i.e., the cost of any equipment which is shared between two or more terminals is assigned in whole to one of those terminals; whenever an FTS night circuit is used, it is assumed that all transactions are over the night circuit, to circumvent this, two data records can be used for one terminal, one containing the number of characters to be transmitted over the night circuit and the other containing the number of characters transmitted over the normal FTS circuit. The program assumes that the total monthly recurring cost is the sum of the monthly line costs, equipment lease costs, and estimated equipment maintenance costs; the total one-time cost is the sum of the equipment purchase costs and shipping/installation charges.

For performance calculations, the program assumes that all transactions are of equal priority, transaction arrivals are Poisson, the number of characters per frame and number

of characters typed-in per transaction are independent variables, that no more than two terminals operate in contention over any given channel, and that terminals in contention are assigned such that the terminal with the largest traffic volume is in contention with the terminal having the smallest traffic volume for a more uniformly distributed workload. The program assumes that the typed-in characters and characters per frame are independent to provide a first approximation to performance. When actual data is available and the relationship between these values is determined, it can be incorporated into the program. For all VIIS networks, no more than two terminals operate in contention; the program can be easily modified to accommodate other arrangements. The program also assumes that the service time for CRT terminals on leased lines is a function of the number of characters and data rate only, that the service time for all teleprinters is equivalent to the connect time; and that all terminals on any one line have the same operating hours, i.e., time zone differences are not considered. The program uses standard queueing equations for determining utilization, wait times, service times, etc. A more detailed description of what the program accomplishes and how it operates follows.

A. COST

The cost of the VIIS communications network is dependent upon several factors. The costs are of two types: one-time expenditures which include the purchase price of any equipment bought plus shipping/installation charges; recurring costs which include monthly charges for leased equipment, anticipated monthly maintenance charges, and monthly charges for the communications lines.

Estimated network costs are determined with the program in the manner described below.

1. For each node in the network, the following data is required as input:

a. The designation of the node in four character alphanumeric code (NO) .

b. The designation of the predecessor node in the network in four character alphanumeric code (NOA) .

c. The type of communication line being used between two nodes as a one character numeric code (L) ; for example, GSA-leased/dedicated lines are coded 1, GSA-leased/shared lines are coded 2.

d. The line numbers in two character numeric code (LINE NO) are then entered. The network is divided into several independent groups of terminals with the only common link being the central processing unit. These sub-networks are basically arranged by geographical areas to minimize the number of miles of leased lines required. The northeastern portion of the United States is on line number 10 and the west coast is line number 60. The second digit is used if the main line is further divided into smaller networks.

e. For those major cities where more than one office requires access to VIIS, an additional four character alphanumeric code is optional (LDESIG) . This provides the capability of distinguishing the District Office functions, Captain of the Port functions, and Marine Inspection functions from each other.

f. Where slow speed teleprinters are operated in contention, a one character alphanumeric code provides the

vehicle by which the program identifies and combines contention terminals (CONTEN).

g. The distance in miles between the last node and the location under consideration is an optional input (DIST). If distances are not provided, telephone company "V" and "H" coordinates should be used as inputs (V),(H). Neither distances nor coordinates are required for FTS lines; charges associated with these lines are a function of connect times only.

h. The estimated traffic volume in thousands of characters per month is required. This figure is the sum of both the characters to be transmitted to the CPU as well as those received at the terminal. In this program, the value read in is in thousands of characters per month (CHARMO).

i. The equipment at each location is read in as a string of two character numeric codes (NEQUIP).

2. For those nodes where distances were not provided, the program will calculate the distance using the "V" and "H" coordinates [6].

$$DIST = (((VA - VB)^2 + (HA - HB)^2)^{1/2} / 10)$$

Total distances are also provided for all GSA-leased dedicated and shared lines.

3. At this point in the program, a selection is made to determine costs of the system based on purchased or leased equipment by use of a three character numeric code (M). If the program is being run in an interactive mode, the user will be queried for this input.

4. The program reads in the number of types of

equipment being used, then reads in the proper set of cost data for each equipment type based upon the selection of purchased or leased equipment. The cost data includes the one-time and monthly recurring costs.

5. The program then determines the one-time (ECOST) and recurring (ECOSTM) equipment costs at each node, the total one-time (TCOST) and recurring (TCOSTM) equipment costs, the total number of each type of equipment in use (NEQUIP), and the number of CRT's, teleprinters, and data access arrangements at each location.

6. At this point in the program, if in an interactive mode, the user is queried for the mean number of characters per frame (XLAM), its standard deviation (XSIG), the mean number of characters to be typed in per transaction (YLAM), its standard deviation (YSIG), the estimated typing rate of the user in characters per second (ZLAM), and the working hours per month (WKHRS). He is also queried for the estimated CPU turnaround times which include queueing time at the CPU, memory cycle times, and disc access times (WLAM). Since the CPU and other computer hardware components have not as yet been specified, only gross estimates for memory cycle, disc access and queueing times are available. The idle time at the terminal can also be included in the WLAM value.

7. The number of line types are read in and the costs associated with each type. The costs for leased lines are in dollars per mile; the costs for FTS lines are in dollars per connect hour.

8. Using the information determined in (5) pertaining to the use of CRT's or teleprinters at a particular location, connect hours per month are calculated (LUSE).

Where CRT's are in use, the connect time determined by the program is

$$\text{LUSE} = (1000 * \text{CHARMO} / ((\text{XLAM} + \text{YLAM}) * 3600)) \\ * (((\text{XLAM} + \text{YLAM}) / 300) + (\text{YLAM} / \text{ZLAM}) + (\text{WLAM}))$$

and for teleprinters, connect time is

$$\text{LUSE} = (1000 * \text{CHARMO} / ((\text{XLAM} + \text{YLAM}) * 3600)) \\ * (((\text{XLAM} + \text{YLAM}) / 30.) + (\text{YLAM} / \text{ZLAM}) + (\text{WLAM}))$$

Total connect hours is also provided (LUSETO). Since all CRT's in VIIS are associated with high speed synchronous transmission and teleprinters with low speed asynchronous transmission, the above equations hold. In adapting this program to another system where all terminals of the same type do not necessarily have the same transmission speeds, different equipment numbers could be assigned to allow for the different speeds.

9. With the connect hours determined in (8) for FTS lines or the distances between nodes determined in (2) for leased lines and the costs associated with each line type from (7), the monthly charges for communications lines are determined (COSLI). Line costs and equipment costs (one-time and recurring) are used to find the total costs associated with each of the independent sub-networks of leased lines, as well as the FTS and DDD network costs. Line costs are also combined with the previously determined total monthly recurring costs (TCOSTM) to provide a final total of recurring costs.

10. The final output includes a listing of the total numbers of each type of equipment, a breakdown of costs by line numbers and individual nodes, and total costs. These cost breakdowns allow the user the opportunity of reviewing all network costs and determining at which locations costs

may be disproportionately high or low for their particular traffic loads. It also gives him an estimate of how much he can save by deleting a terminal site or how much more it will cost to install additional terminals in the network. Since the user has the opportunity to vary several parameters, particularly those which affect the connect hours, he has the ability to develop a range of costs associated with the network.

B. PERFORMANCE

Communications network performance is based largely on the number of characters transmitted and the transmission rate. For asynchronous transmission, performance is dependent upon total connect times since the entire channel bandwidth is being utilized. For synchronous transmission, performance is dependent upon the amount of time that there are actually characters being transmitted. Much of the information required to determine performance was also used to determine costs. The equations that follow for determining performance are from standard queueing theory models in use today.

1. The first step in determining performance is the separation of terminals by line types and line numbers. For those locations having CRT's, the FTS lines, and the DDD lines, the characters per month for all terminals on that line are summed to provide the total traffic volume in thousands of characters for the line (CHAR). In the case of teleprinters which have been frequency division multiplexed, each terminal has its own channel and the total traffic in the channel is limited to that of the one terminal, except where terminals operate in contention. When in the contention mode, two terminals share one channel and the

traffic volume for the channel is the sum of the individual traffic loads. When more than one channel of a line is being utilized in a contention mode, the program pairs the locations with the highest and lowest traffic loads, next highest and next lowest, etc., to achieve a more uniform workload distribution for the channels.

2. The next step is to determine the mean service time per transaction (TS). For teleprinters and FTS or DDD CRT's, the service time bandwidth is used while connected. For CRT's on dedicated lines, separate service times are determined for the typed-in information and the information received from the CPU.

$TS = XLAM / 300$. for data received from the CPU.

$TS = YLAM / 300$. for typed-in data.

3. The average number of transaction arrivals per second (EN) is determined using the total number of characters on the line, the number of characters per transaction, and the number of working hours per month [6, 10].

$EN = ((1000 * CHAR) / ((XLAM + YLAM) * WKHRS * 3600.))$

4. Line utilization (RHO) is the percent of time that the communication line is actually in use. It is determined as the product of the mean service time per transaction and the number of arrivals per second [6, 10].

$RHO = TS * EN$

5. The number of transactions waiting for service in the system (EW) is a function of the utilization, the

expected arrivals per second, and the standard deviation of the characters per frame and typed-in characters [6, 10].

$$EW = ((EN * SIGMA)^2 + RHO^2) / (2 * (1 - RHO))$$

6. The number of transactions in the system (EQ), waiting for service or being served, is the sum of those waiting for service and the utilization [6, 10].

$$EQ = EW + RHO$$

7. The expected waiting time for service (ETW) is the quotient of the number of items waiting for service and the expected arrival rate [6, 10].

$$ETW = EW / EN$$

8. The expected time an item spends in the communications network (ETQ), waiting for service and being served, is the sum of the expected service times and expected waiting times [6, 10].

$$ETQ = ETW + TS$$

9. The performance data output is of great value in determining line usage and possible problem areas, such as over-utilization which degrades response times to the point where additional lines may be required. Since the size of the data base transaction frames and the number of characters to be typed in has not been well defined, the ability of the user to input various frame sizes and typed-in character values as well as their standard deviations, provides the user the opportunity of reviewing network utilization under a wide range of operating conditions. The general nature of the performance section of the program allows the user to get information on utilization from the best conditions where service times are constant to the worst case where they are exponentially distributed. For teleprinters, the ability to vary typing

speed and the CPU turnaround times also provides the user the opportunity to check performance of the system under various operating conditions. The performance data does have the following drawback, it does not account for time zone/working hours differences between terminal locations. For leased lines and DDD lines, this is not significant since all terminals are in the same geographical areas; for FTS lines however, terminals are spread from the east coast of the United States to Guam and performance can actually be significantly better than that determined by the program.

IV. COMMUNICATIONS NETWORK SENSITIVITY ANALYSIS

The sensitivity analyses that follow are based on the Baseline Network using mixed terminal types. Comparisons are made against the original cost and performance estimates provided in the report on VIIS made to the Coast Guard. The following parameters were used for the original estimates:

A typing rate of 3.0 characters per second, assuming only qualified clerical staff operated the terminals.

An average of 2200 characters per transaction.

There were no mileage charges associated with the GSA-leased/shared lines. The total cost for these lines would be born by present users of these lines.

Due to the very high connect time charges on the FTS-nonCCNUS lines, \$66.00 per connect hour, data transmission is pursued after business hours, whenever possible, to take advantage of the FTS night circuit rates, \$125.00 per month independent of connect hours.

A response time of 5 seconds or less is desired on all lines utilizing CRT's.

A. COST

The cost of the communications network is derived from two sources, equipment costs and line costs. Line costs can

further be divided into mileage charges for leased lines and connect time charges for FTS lines. Variations of cost with respect to equipment and connect times are discussed below.

1. Purchased Equipment

In the baseline network utilizing purchased equipment, the one-time costs are only affected by manufacturers' price changes and shipping/installation price changes. Appendix A lists several equipment types and illustrates the resultant effect on the total one-time costs with changes in equipment costs. The original estimate was \$337,300.

Changes in the cost of the teleprinters with built-in couplers have the greatest impact on the total one-time costs, 2.4% change in total costs for a 10.0% change in unit cost of the teleprinter. The total cost is relatively insensitive to price changes of individual types of equipment unless the change is a major price increase or decrease. The prices of several types of equipment increasing simultaneously could have an adverse combined effect on the total costs.

The monthly recurring costs are affected by the FTS connect hours, leased line mileage charges, maintenance charges, and common carrier service charges for conditioning and terminations. Appendix B provides a list of several items contributing to the monthly recurring costs and the impact price changes for those items would have on the total recurring costs.

If VIIS is required to share the cost of the GSA leased/shared lines, the recurring costs could change by as much as 8 %. The details of the shared line arrangement

have not been worked out and the share of the costs that VIIS will have to bear have yet to be determined.

The monthly recurring costs are affected for the most part by changes in line costs for which there is little or no control, and the FTS connect hours. The connect hours are a function of the number of transactions per month, the typing rate of the user, the access and queueing times of the host computer, and the number of characters in a transaction. Figures 1. thru 3. show the relationship between access times, typing rates, the number of characters typed, connect hours, and cost.

FTS connect charges can be reduced by using the FTS night circuit for all transactions that do not require real-time responses, use of CRT's instead of teleprinters (this particularly applies to non-CONUS terminals where a reduction in connect time of one hour will cover the rental cost of a higher speed modem required for the CRT), reducing the number of transactions entered from these terminals, or reviewing the requirements for each type of transaction and reducing the number of characters per transaction whenever possible.

2. Leased Equipment

The discussion in the last section applies here as well except that the recurring costs are substantially higher, and the impact of a price change for a particular piece of equipment or line results in a smaller percentage change in the total recurring costs. See Appendix C.

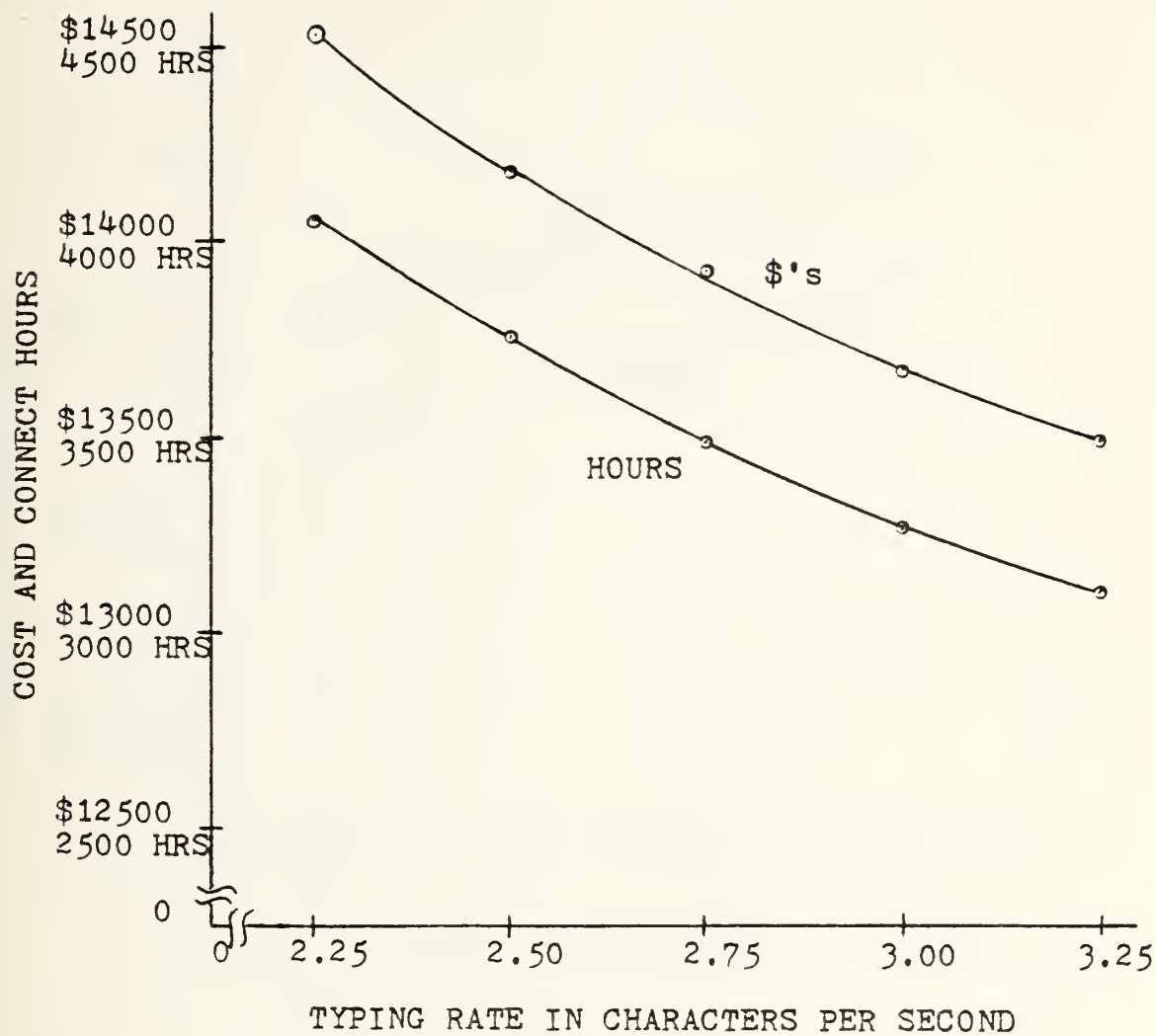


Figure 1 - TYPING RATE VS. COST AND CONNECT HOURS

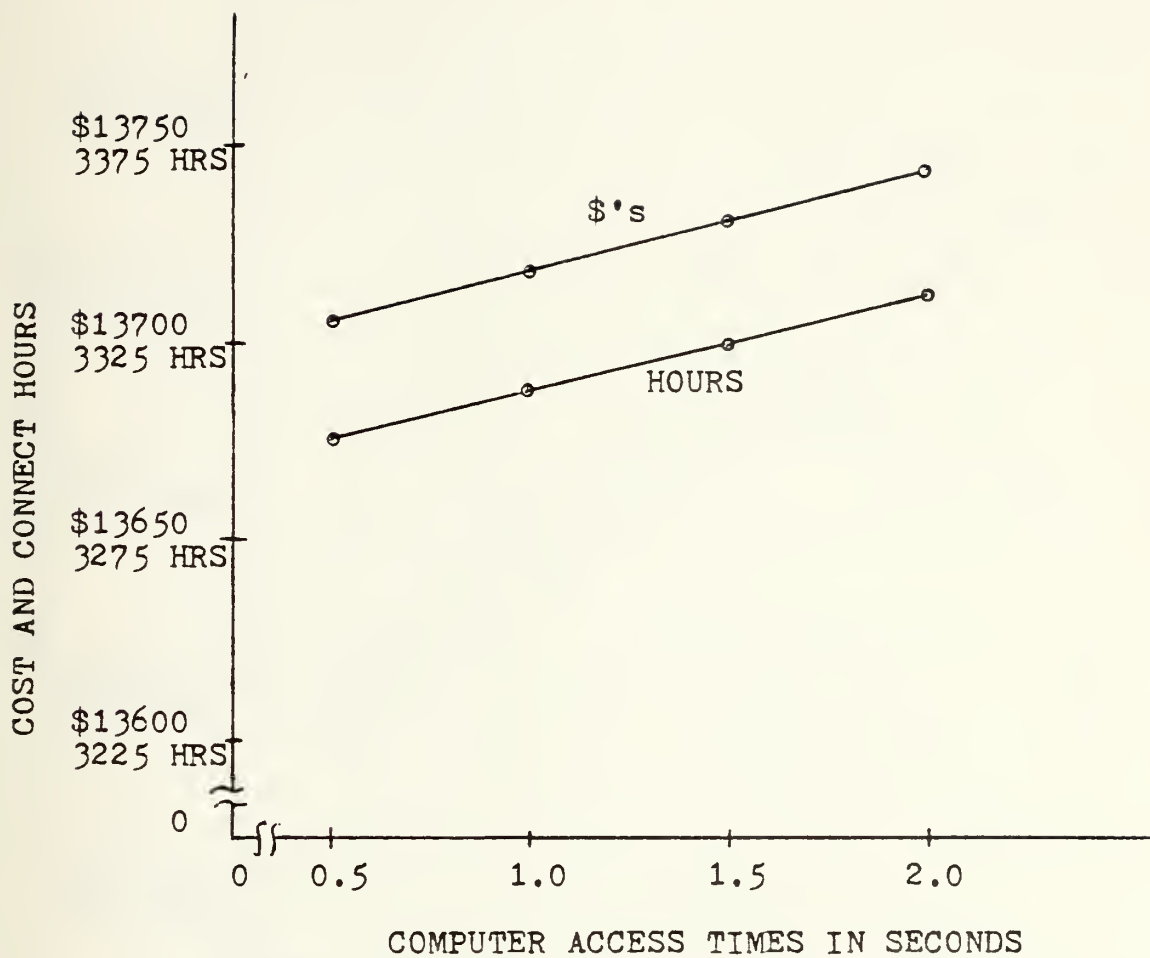


Figure 2 - COMPUTER ACCESS TIME VS. COST AND CONNECT HOURS

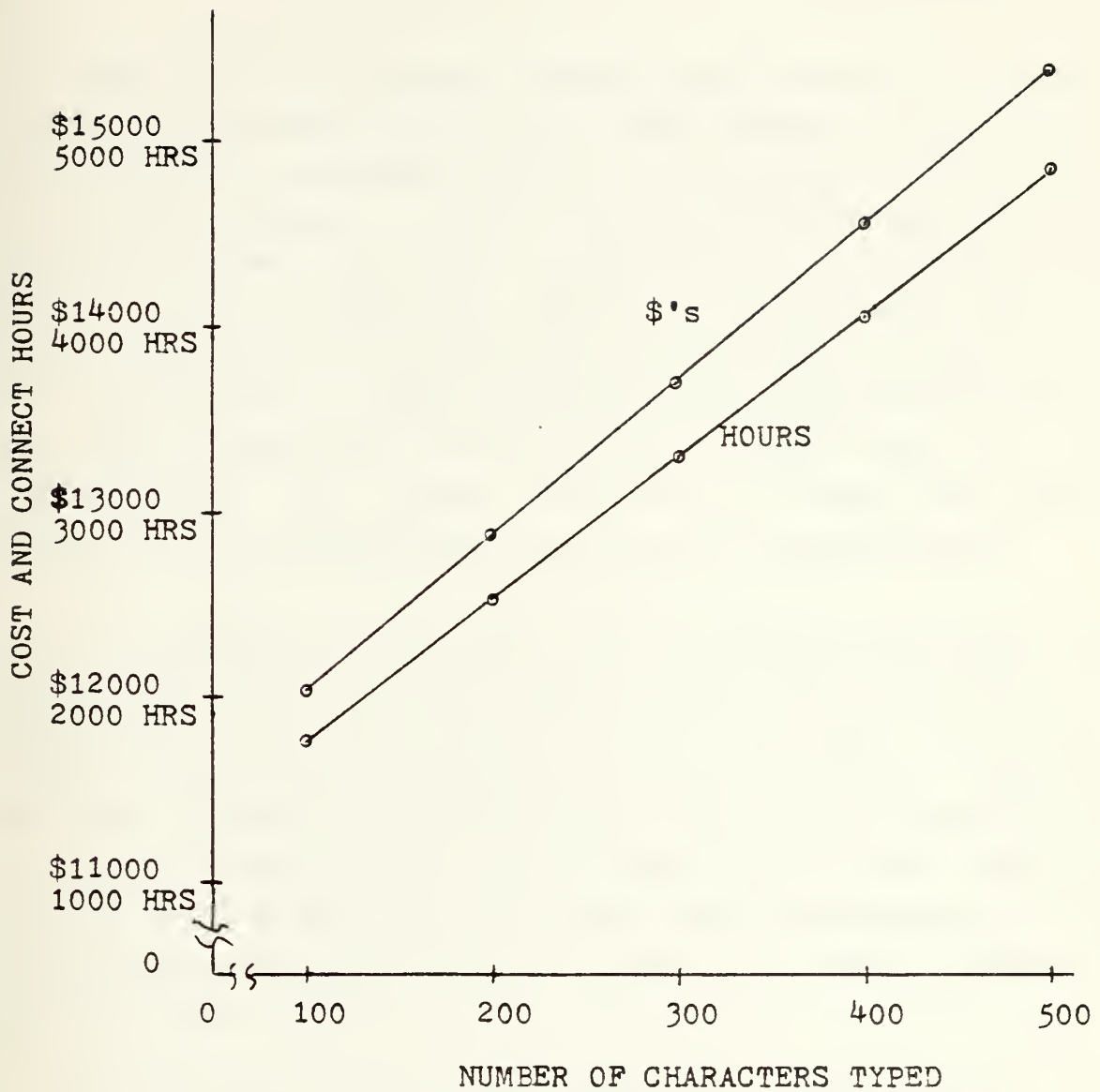


Figure 3 - NUMBER OF CHARACTERS TYPED VS. COST AND CONNECT HOURS

B. PERFORMANCE

There is no distinction between the purchased or leased equipment networks as far as performance is concerned. Performance is dependent upon the transmission rates of the lines and equipment, and the typing speed of the user and computer access times where asynchronous transmission is used. Another important aspect of performance which is often neglected is the variation in the number of characters per transaction. These variations can significantly alter the waiting times for service and the total time in the system from the values obtained by using only mean characters per transaction in performance calculations.

In reviewing performance in the baseline network, two independent lines were considered. One line involves two teleprinter terminals operated in contention. The total number of characters transmitted per month is 3441 thousand and they operate asynchronously with a data transmission rate of 30 characters per second. The other line includes four CRT terminals with synchronous data transmission of 300 characters per second and a total of 42322 thousand characters per month.

A mean frame size of 1900 characters, approximately one full CRT screen of data, and a mean of 300 characters of typed-in data were selected as starting points for performance evaluation. This gives the suggested mean number of characters per transaction of 2200. Figures 4 and 5 show the effect of the variance of the frame size and number of typed-in characters respectively, on system performance in terms of the expected time in the network per transaction.

Since the asynchronous terminals operate at a low data rate and occupy the full channel bandwidth, which means that any time the terminal is connected the network is in use, the expected time in the network starts out high and increases gradually as the standard deviation increases. If the number of characters transmitted over this line was increased, the expected time in the network would increase at an increasing rate, i.e., performance deteriorates at an increasing rate. The bulk of the time in the network with these terminals is due to the typing rate and low data rate. Reducing the number of transactions per month will not affect performance to a high degree, but will flatten out the curve slightly when the standard deviation is increased. The same applies to the number of characters per transaction. The greatest decrease in time in the network without changing equipment can be achieved through a decrease in the number of characters typed in. See Figure 6. The most effective way of reducing time in the network and improving performance is by using CRT's, synchronous high speed transmission, etc.; however, the additional costs involved may not be justified because of the low number of transactions.

The performance of the line using CRT's is at the desired response time level for transactions having zero standard deviation, constant frame sizes and number of typed-in characters, and remains virtually constant over the range of standard deviation considered. On this line, total utilization is under 25 per cent and is the major factor responsible for the insensitivity of the line's performance to variations in transaction size. If in actual use, the number of transactions was significantly higher than expected and caused network degradation, the data rate of the line and terminals could be increased or the transactions split between two or more lines to improve performance.

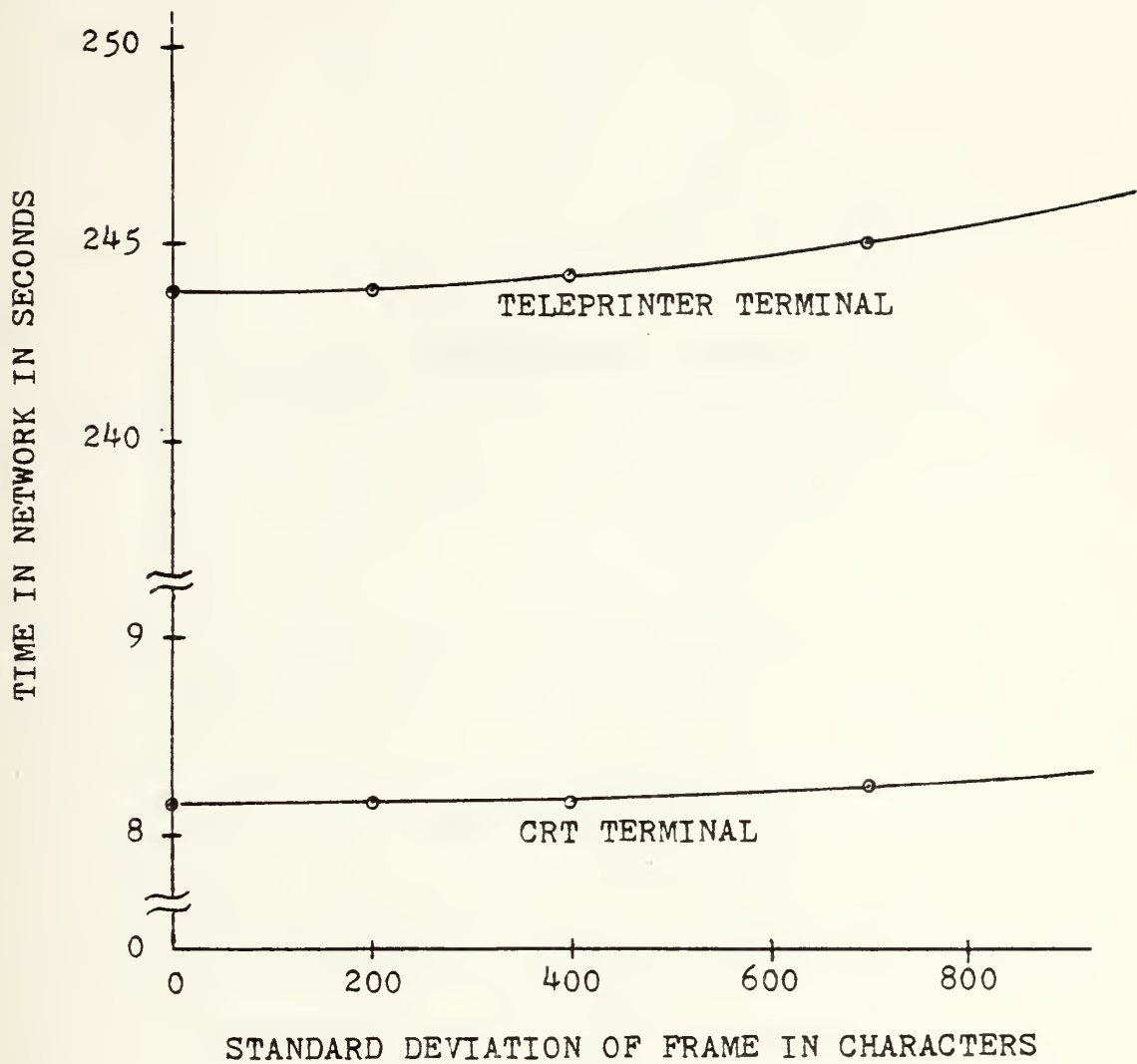


Figure 4 - TIME IN NETWORK VS. STANDARD DEVIATION OF FRAME SIZE

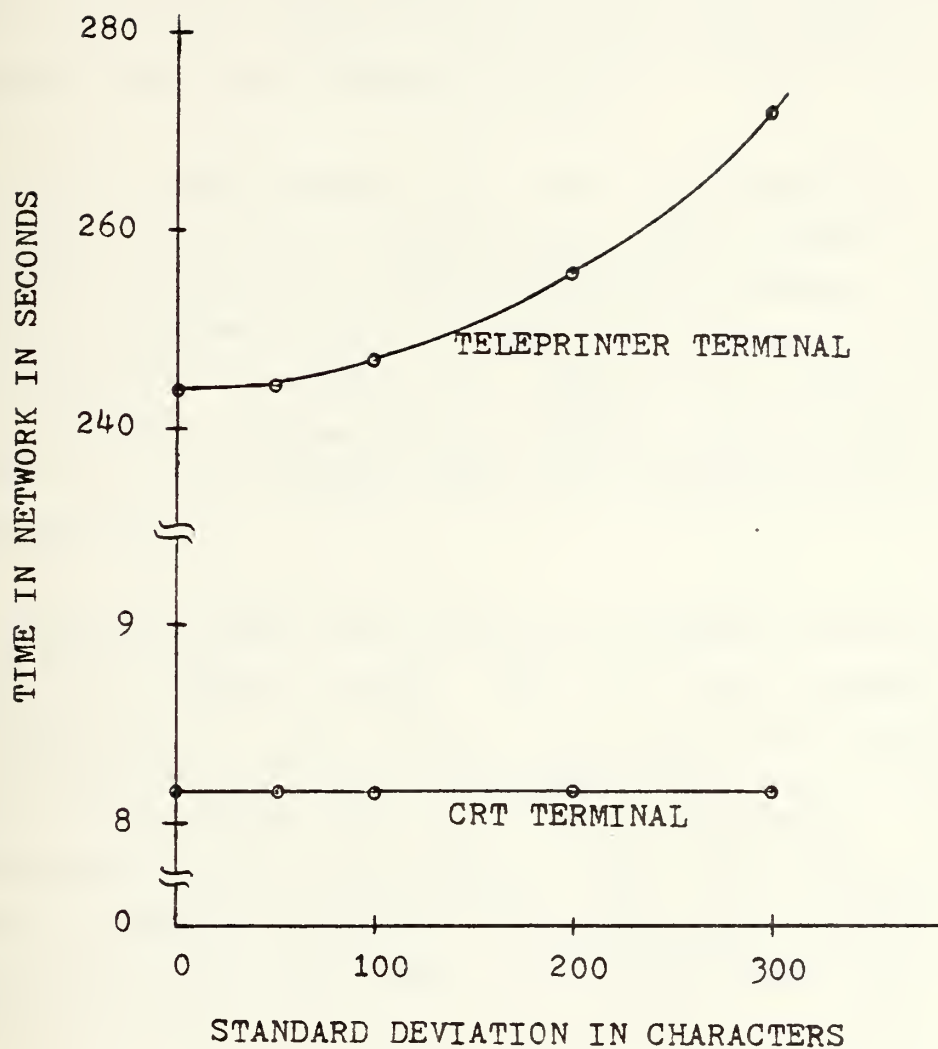


Figure 5 - TIME IN NETWORK VS. STANDARD DEVIATION OF NUMBER OF TYPED IN CHARACTERS

Figure 6 shows the relationship of the two lines with the number of characters typed in, still assuming 2200 total characters per transaction. The performance of the CRT's remains relatively constant, as expected, for each of the standard deviations considered, since the typing rate is not a factor in network performance utilizing synchronous transmission over dedicated lines.

The performance of the asynchronous terminals deteriorates with an increase in the number of typed-in characters because performance is dependent upon typing rate. Performance can be improved somewhat by arranging transactions to have as few typed in characters as possible or by typing transactions off-line onto auxilliary tape units and then transmit them over the lines at 30 characters per second.

Figure 7 shows the time in the network using half duplex and full duplex lines. Due to the relatively low utilization of the line, the time in the network for the half-duplex line is only slightly higher than that of the full-duplex line for all cases considered. The actual performance of the half-duplex line is actually somewhat poorer than that indicated since the time required to switch the line from the send to receive mode has not been included.

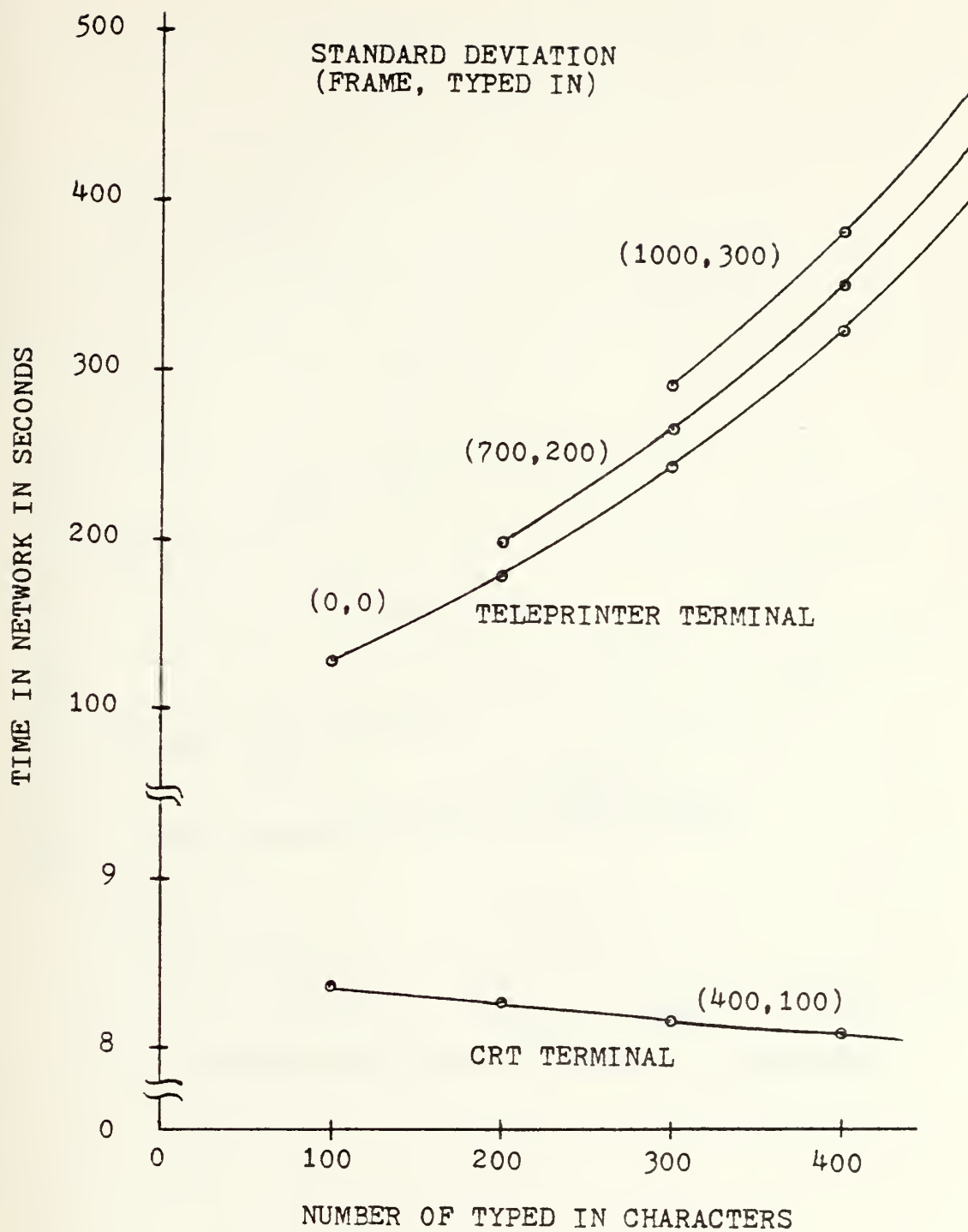


Figure 6 - TIME IN NETWORK VS. NUMBER OF TYPED IN CHARACTERS

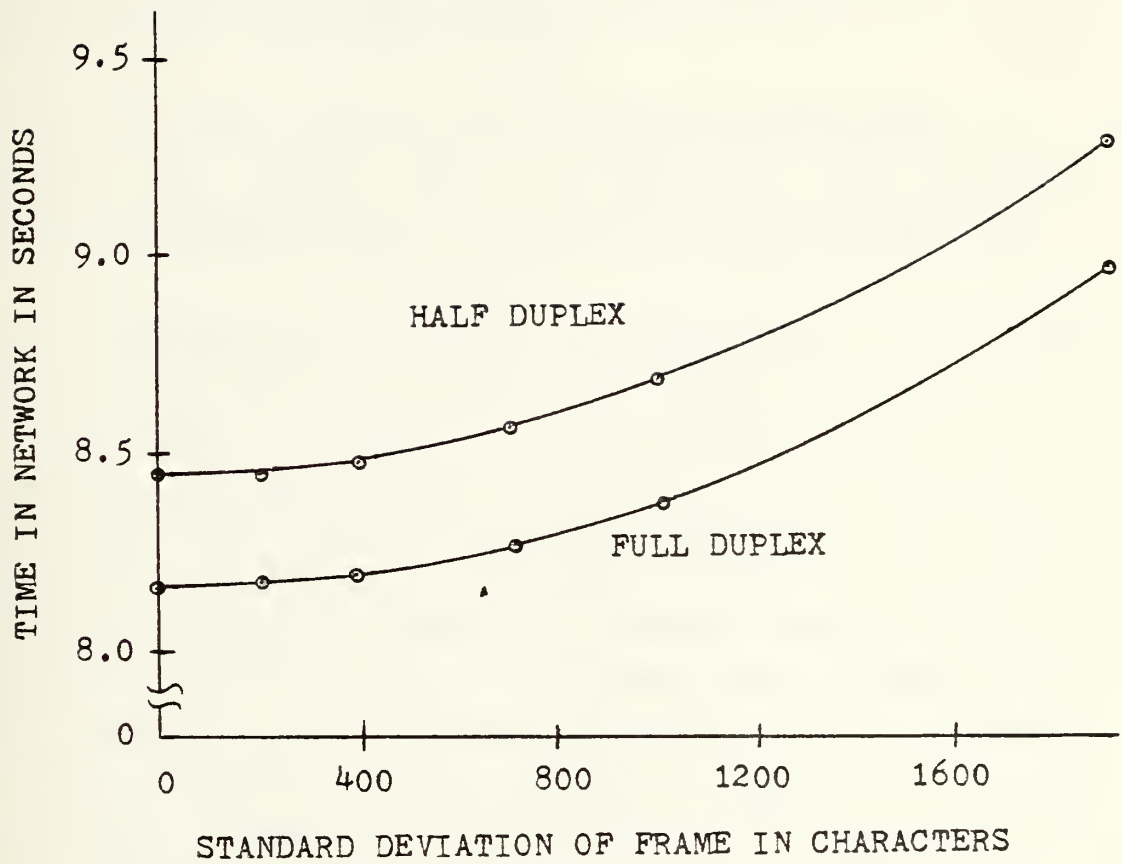


Figure 7 - TIME IN NETWORK FOR HALF AND FULL DUPLEX LINES

V. CONCLUSION

A Vessel Inspection Information System, properly designed, implemented and utilized, could prove to be an invaluable tool for the execution of the Coast Guard's Merchant Marine Safety Functions.

The estimated costs of the proposed system appear to be accurate and, except for the costs of the FTS lines, relatively constant over a range of operating conditions.

The response of the lines utilizing CRT's was estimated to be near real-time as desired and relatively constant over a wide range of operating conditions. With the low utilization of these lines, there is little problem in maintaining the desired response times as far as the communications network is concerned. For the teleprinter terminals, response times are greater than for CRT's, as expected, but user needs at low transaction volume locations are satisfied. Caution must be exercised at teleprinter locations to ensure that the number of transactions is kept low enough to keep utilization down. Some lines utilizing teleprinters are operating at 50 per cent utilization and are more sensitive to variations in transaction size or increased numbers of transactions.

An area requiring further research is that of computer access and service times. Several values for these times were used to get an indication of their effect on connect times of all lines and performance for all asynchronous terminals; however, if performance at the CPU deteriorates significantly with varying transaction sizes, time in the

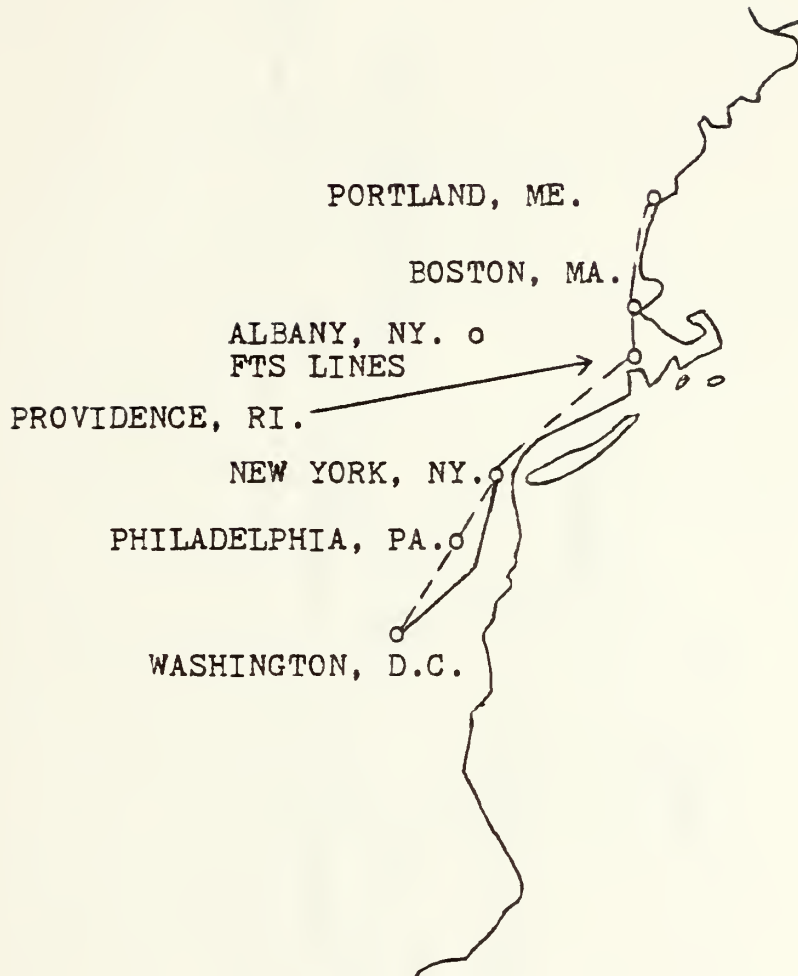
network could be much longer than the times which have been determined.

Finally, if the Baseline System is constructed and larger systems are developed from it at a later date, the additional transactions could have a degrading effect on communications network performance. Prior to expanding the baseline network, additional performance data should be obtained, using data from the Baseline System.

Upon completion of further study of the computer part of the system, including queueing, access, and response times, and upon completion of a cost-effectiveness study of the system to ensure its worth to the Coast Guard, implementation of the baseline system should be considered.

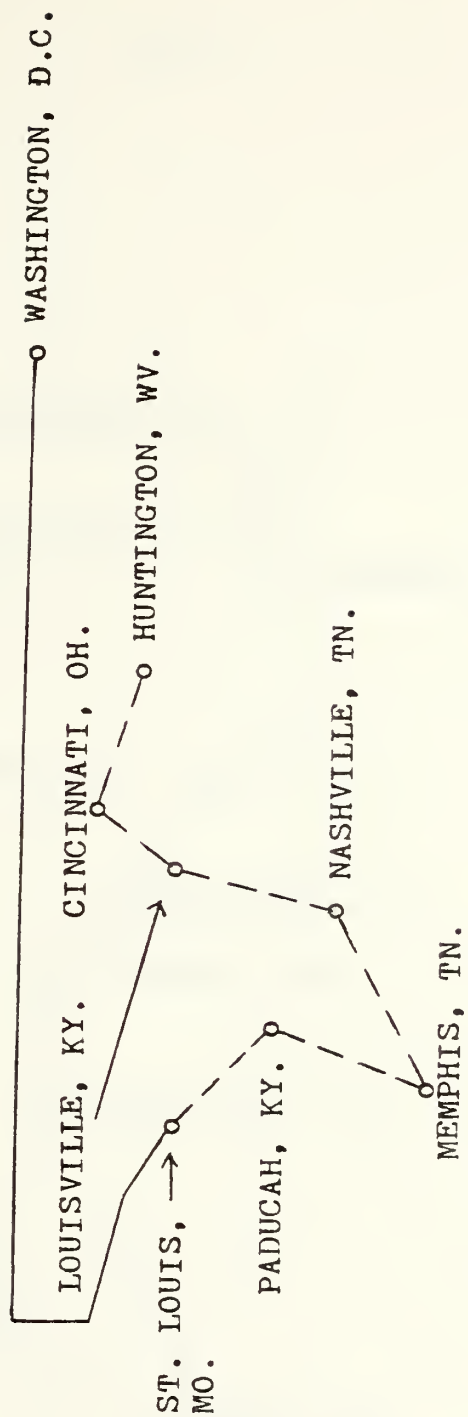
APPENDIX A
VIIS NETWORK

LINE 1



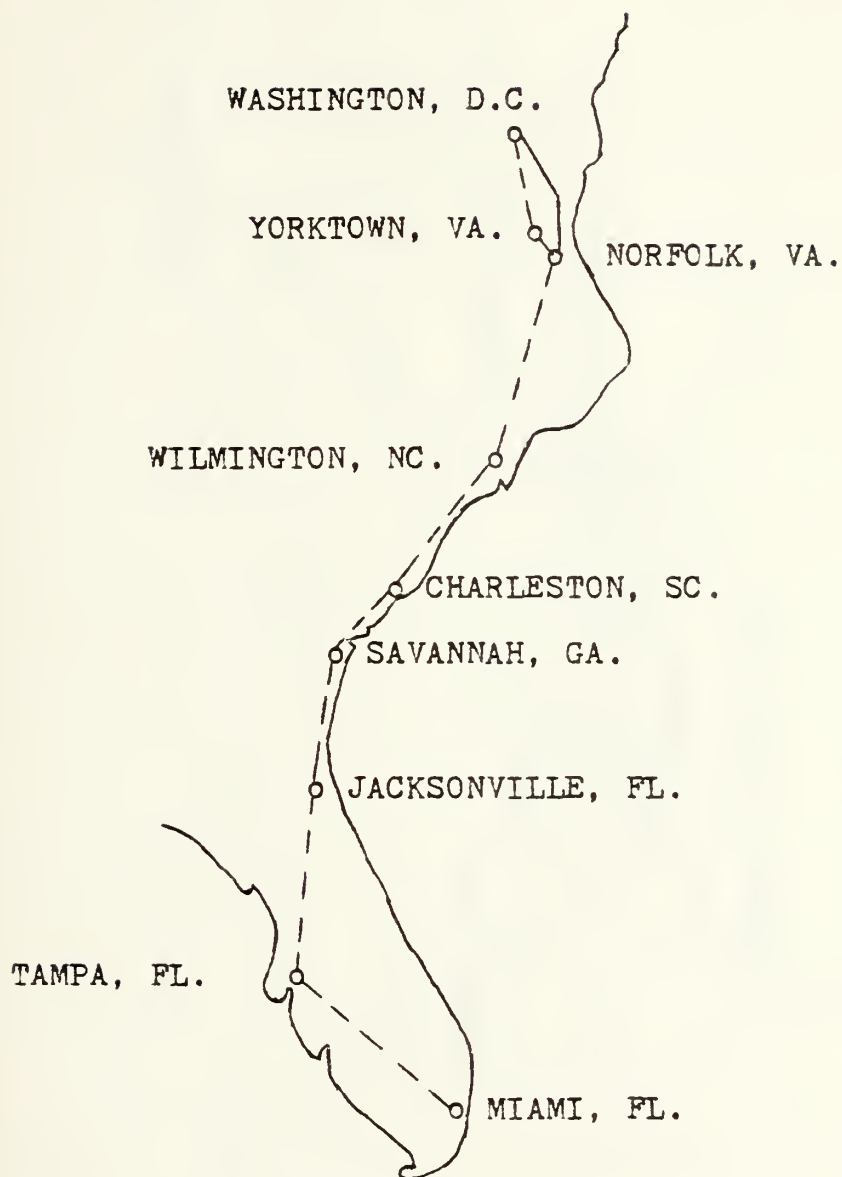
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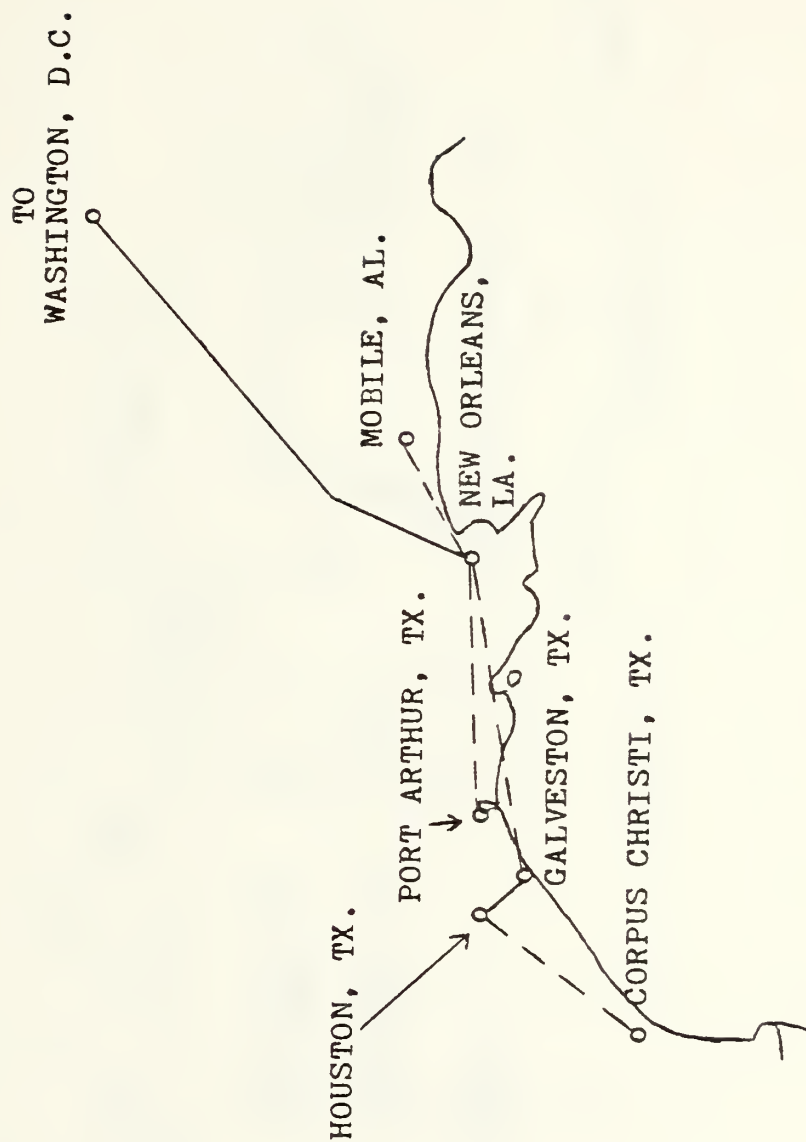
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LINE 3

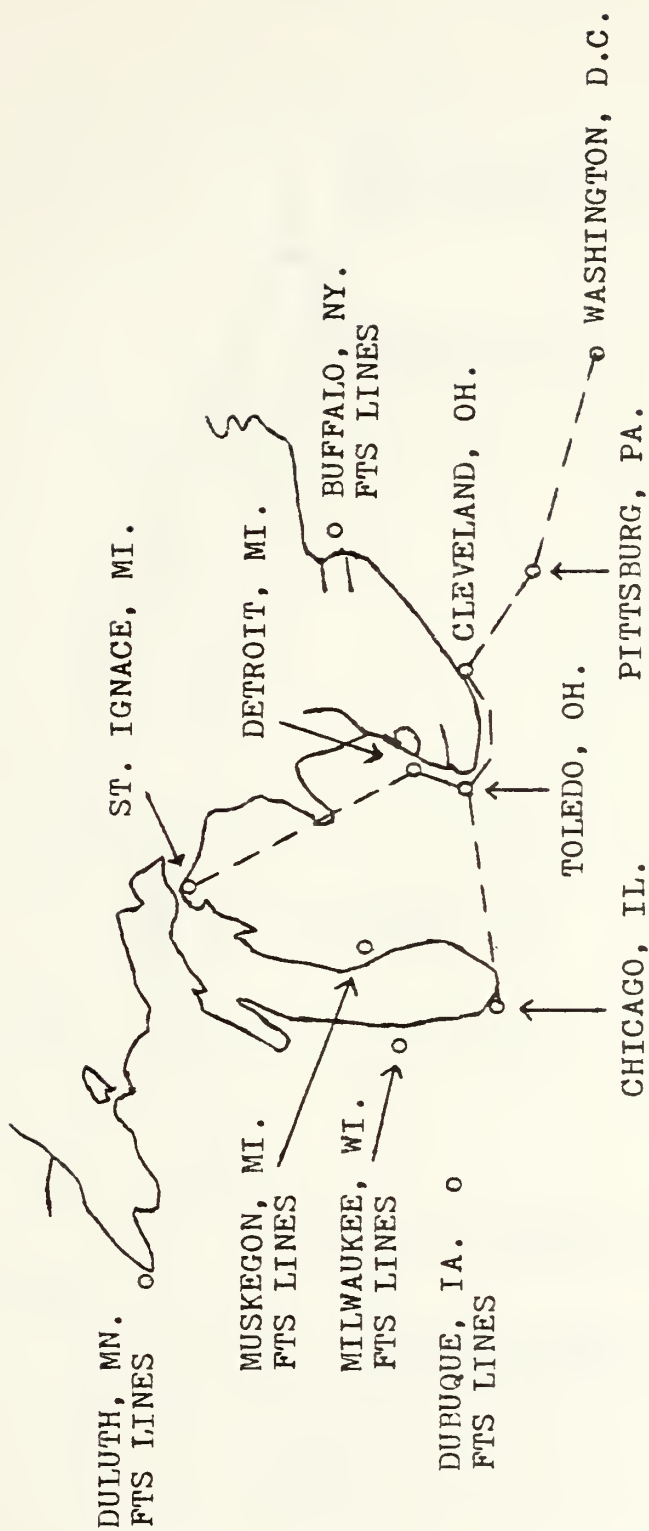


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LINE 4



REF: 4



REF: 4

LINE 6

○ ANCHORAGE, AK.
FTS LINES

○ JUNEAU, AK.
FTS LINES

○ SEATTLE, WA.

○ PORTLAND, OR.

○ SAN FRANCISCO, CA.

○ GUAM
FTS LINES

○ HONOLULU, HI.
FTS LINES

○ LOS ANGELES, CA

TO
ST. LOUIS,
MO.

○ SAN DIEGO, CA.

REF: 4

APPENDIX B

BASELINE - PURCHASED EQUIPMENT VARIATIONS OF ONE-TIME COSTS WITH CHANGES IN EQUIPMENT PRICES

BASE COST OF 337,300

EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
A300 MODEM	23	570.	+10.	627.	338,610.	+0.39
S2400 MODEM	15	2138.	+10.	2352.	340,510.	+0.95
S560C MODEM	4	9600.	+10.	10560.	341,140.	+1.14
CRT	12	1850.	+10.	2035.	339,520.	+0.66
TELEPRINTER	15	2130.	+10.	2343.	340,500.	+0.95
TELEPRINTER w/COUPLER	34	2430.	+10.	2673.	345,560.	+2.45
PRINTER	7	3625.	+10.	3988.	335,840.	+0.75
FDM CHASSIS	39	480.	+10.	528.	335,170.	+0.56
FDM CHANNEL	61	350.	+10.	385.	339,440.	+0.63
TDM CHASSIS	4	1700.	+10.	1870.	337,980.	+0.20
TDM CHANNEL	28	300.	+10.	330.	338,140.	+0.25

REF: 4

APPENDIX C

BASELINE - PURCHASED EQUIPMENT VARIATIONS OF RECURRING COSTS WITH CHANGES IN EQUIPMENT/SERVICE COSTS

BASE COST OF 13,100

EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
LEASED LINES /DEDICATED	6595.MI	0.54/MI	+10.	0.594/MI	13480.	+2.88
LEASED LINES /SHARED	2030.MI	0.00/MI		0.27/MI	13650.	+4.18
C2 LINE CONDITIONING	4	49.	+10.	53.90	13120.	+0.15
LINE TERMINATION	53	42.	+10.	46.20	13340.	+1.86

REF: 4

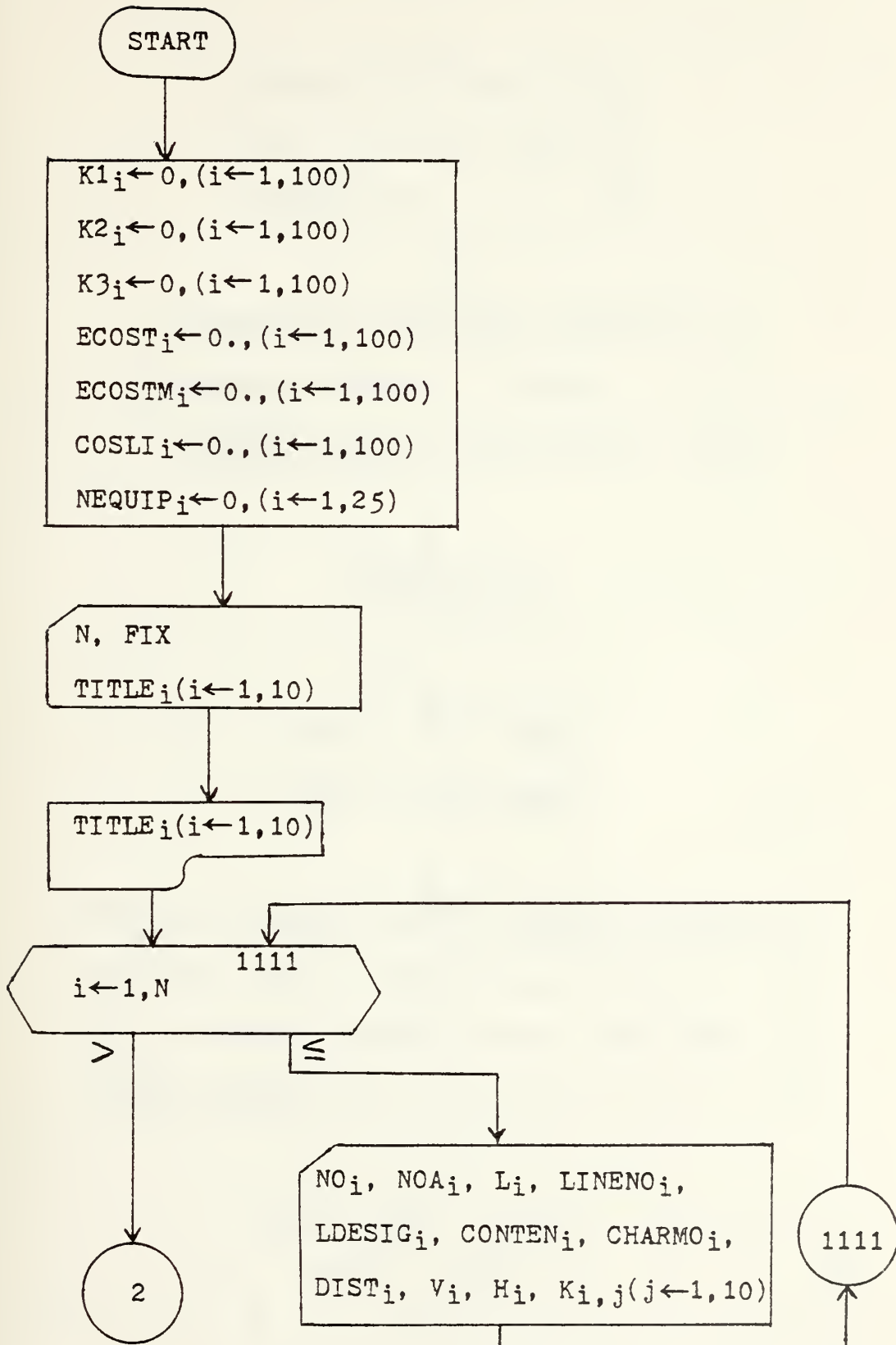
APPENDIX D

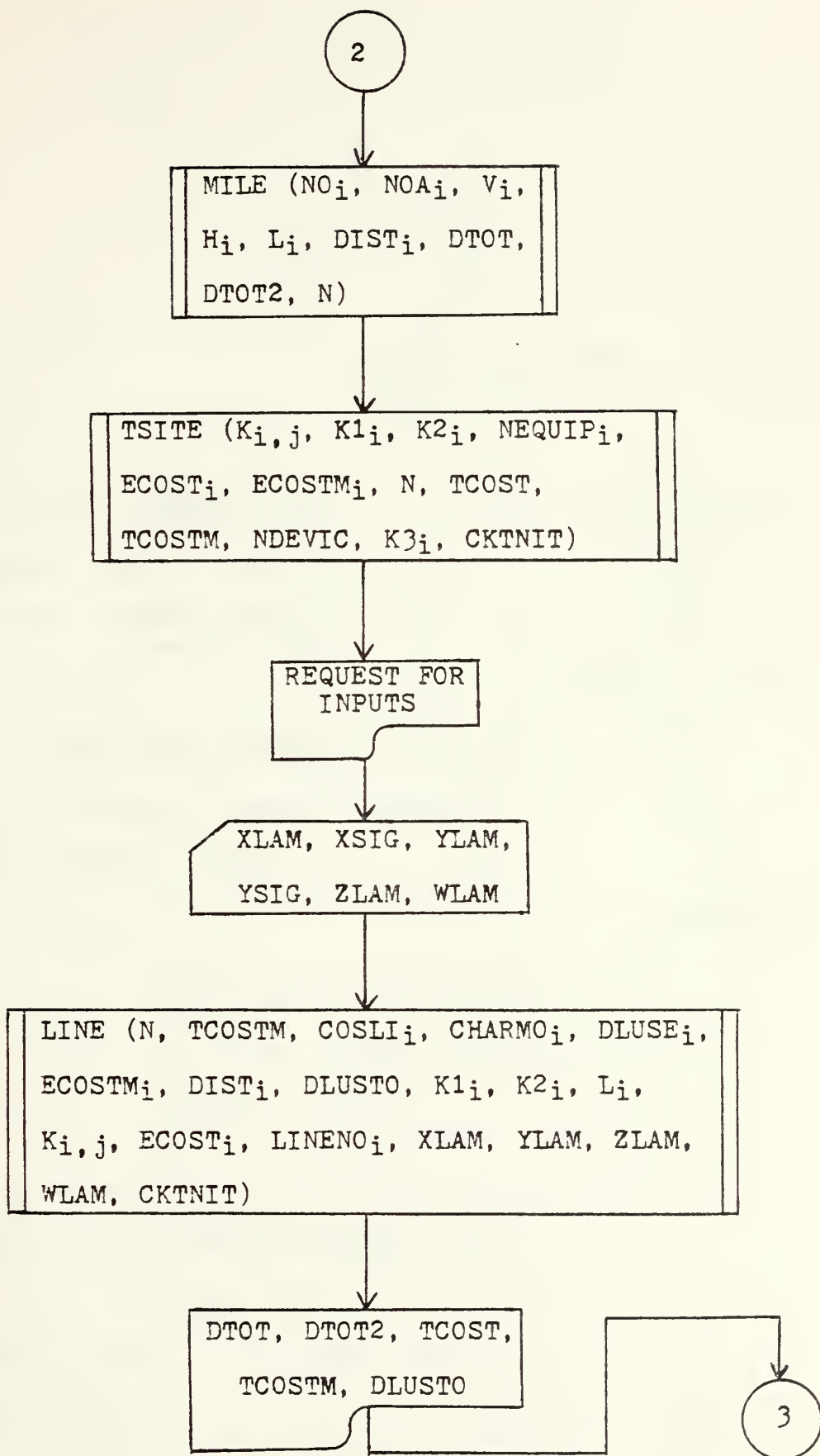
BASELINE - LEASED EQUIPMENT VARIATIONS OF RECURRING COSTS WITH CHANGES IN EQUIPMENT/SERVICE COSTS

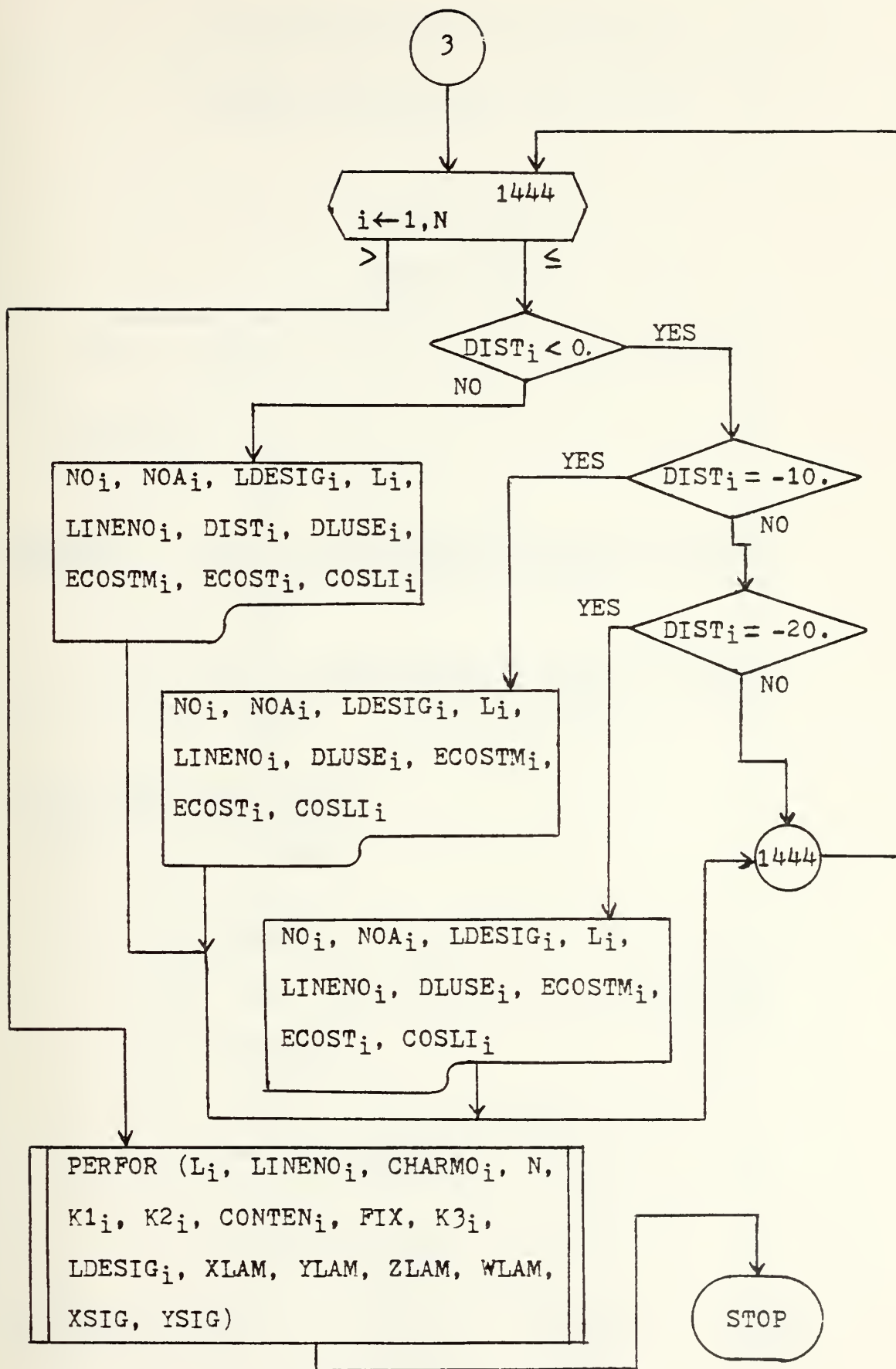
BASE COST OF 21,620

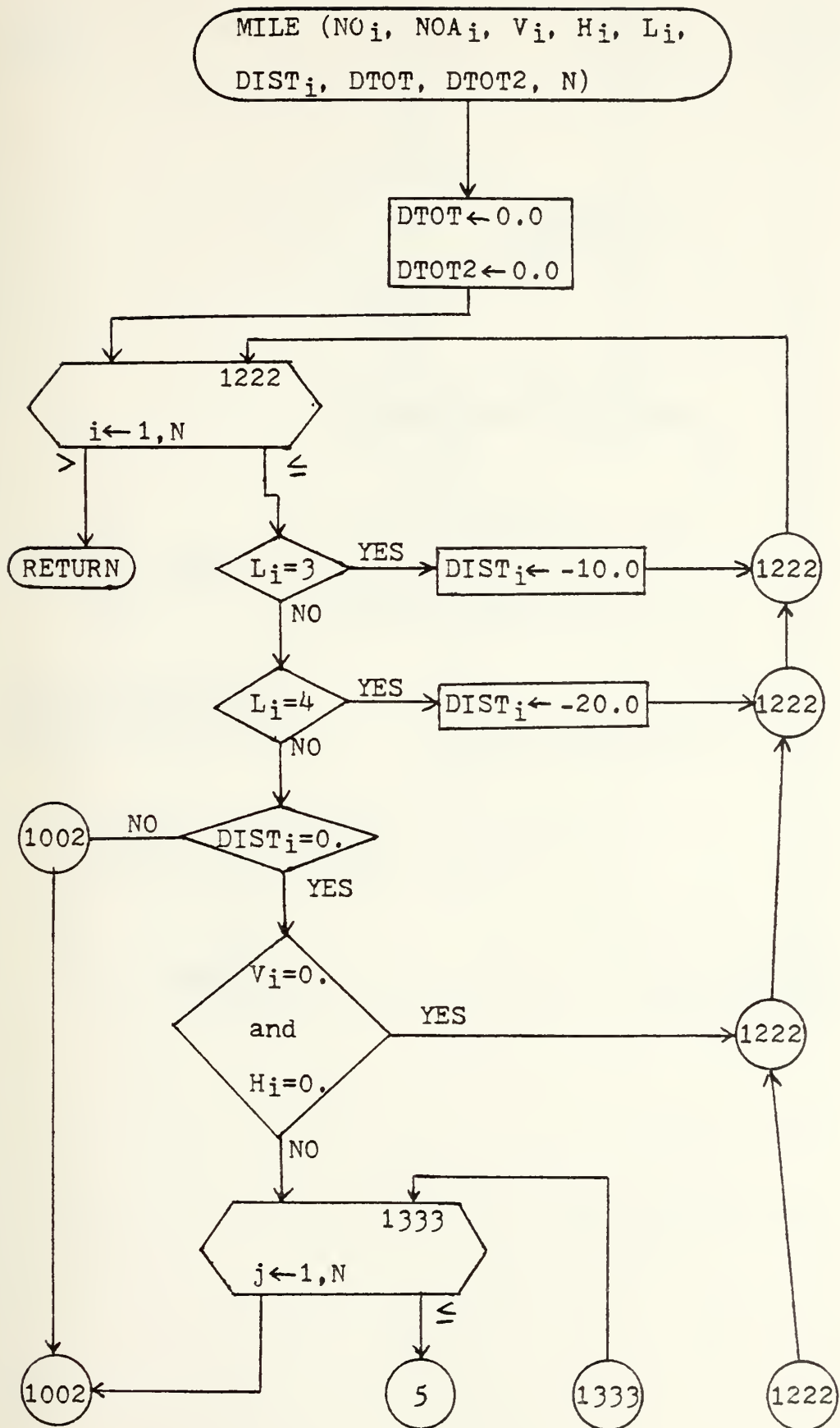
EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
A300 MODEM	23	12.	+10.	13.20	21810.	+0.13
S2400 MODEM	15	55.	+10.	60.50	21860.	+0.38
S5600 MODEM	4	230.	+10.	253.	21870.	+0.42
CRT	12	83.	+10.	91.30	21880.	+0.46
TELEPRINTER	15	95.	+10.	104.50	21920.	+0.65
TELEPRINTER W/COUPLER	34	107.	+10.	117.70	22140.	+1.67
PRINTER	7	170.	+10.	187.	21900.	+0.55
FDM CHASSIS	39	16.	+10.	17.60	21840.	+0.29
FDM CHANNEL	61	11.	+10.	12.10	21850.	+0.31
TDM CHASSIS	4	52.	+10.	57.20	21800.	+0.09
TDM CHANNEL	28	10.	+10.	11.	21810.	+0.13
LEASED LINES /DEDICATED	6995.MI	0.54/MI	+10.	0.594/MI	22160.	+1.73
LEASED LINES /SHARED	2030.MI	0.00/MI		0.27/MI	22330.	+2.52
LINE TERMINATION	53	42.	+10.	46.20	22000.	+1.02
C2 LINE CONDITIONING	4	49.	+10.	53.90	21800.	+0.09

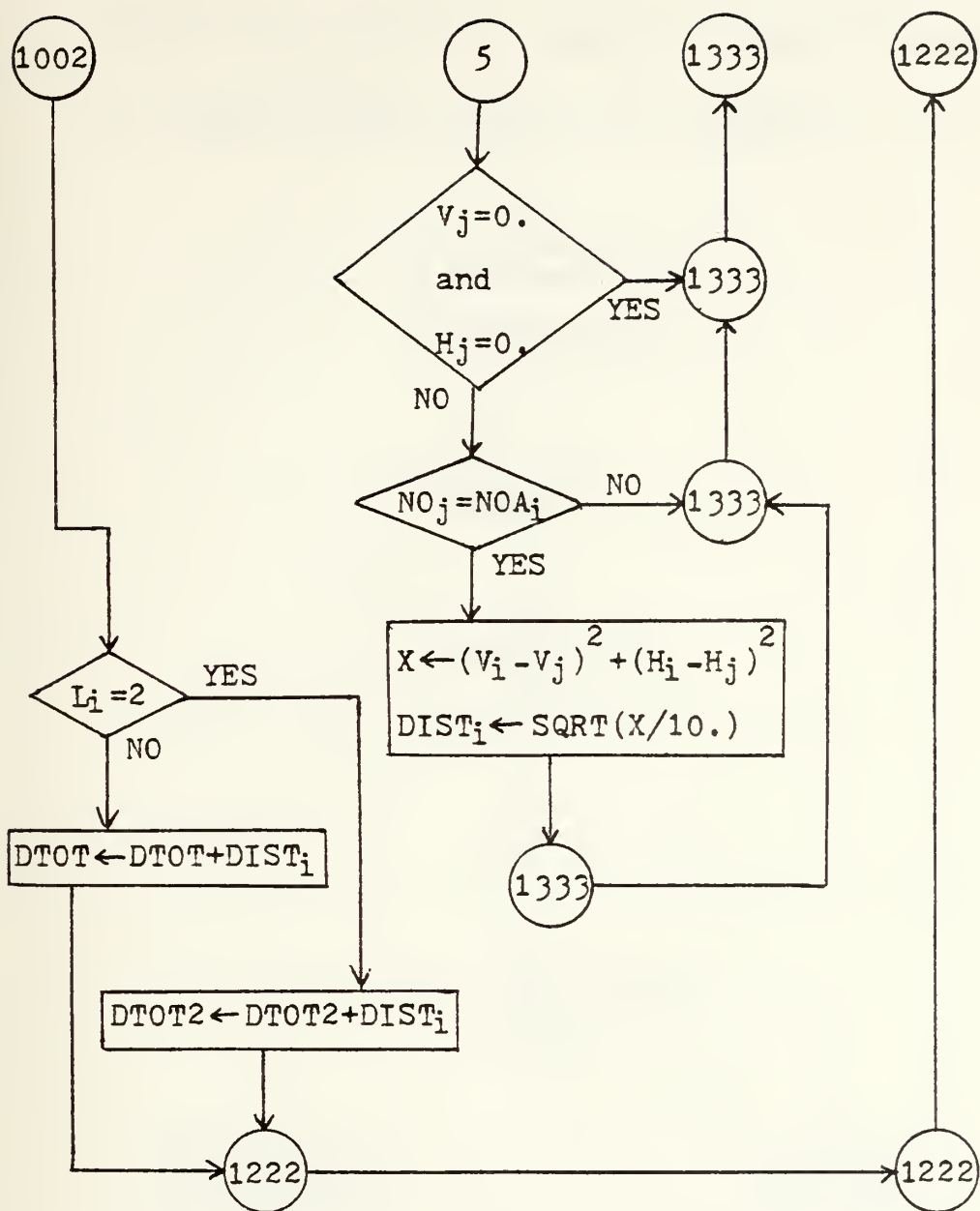
APPENDIX E
PROGRAM FLOWCHARTS



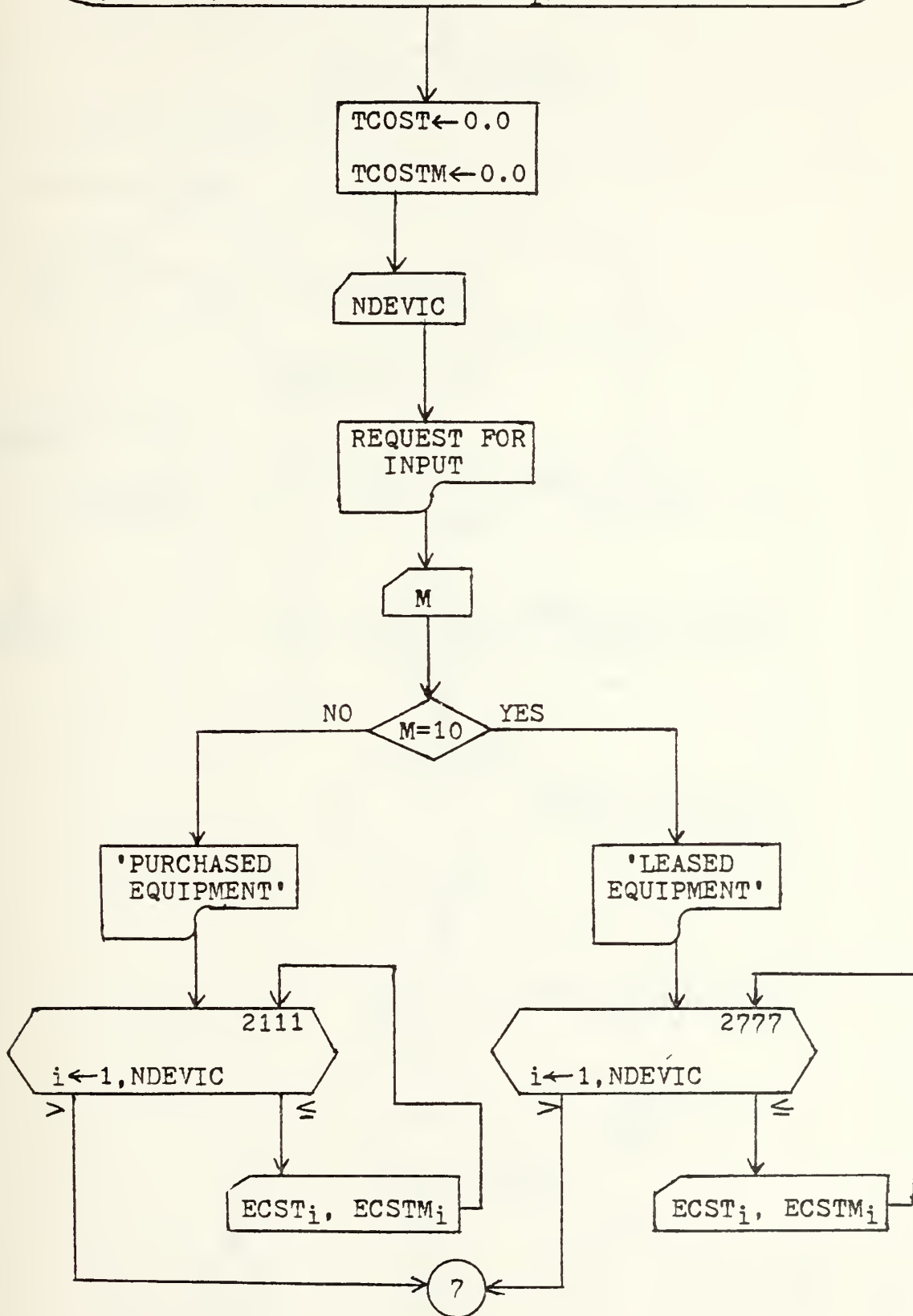


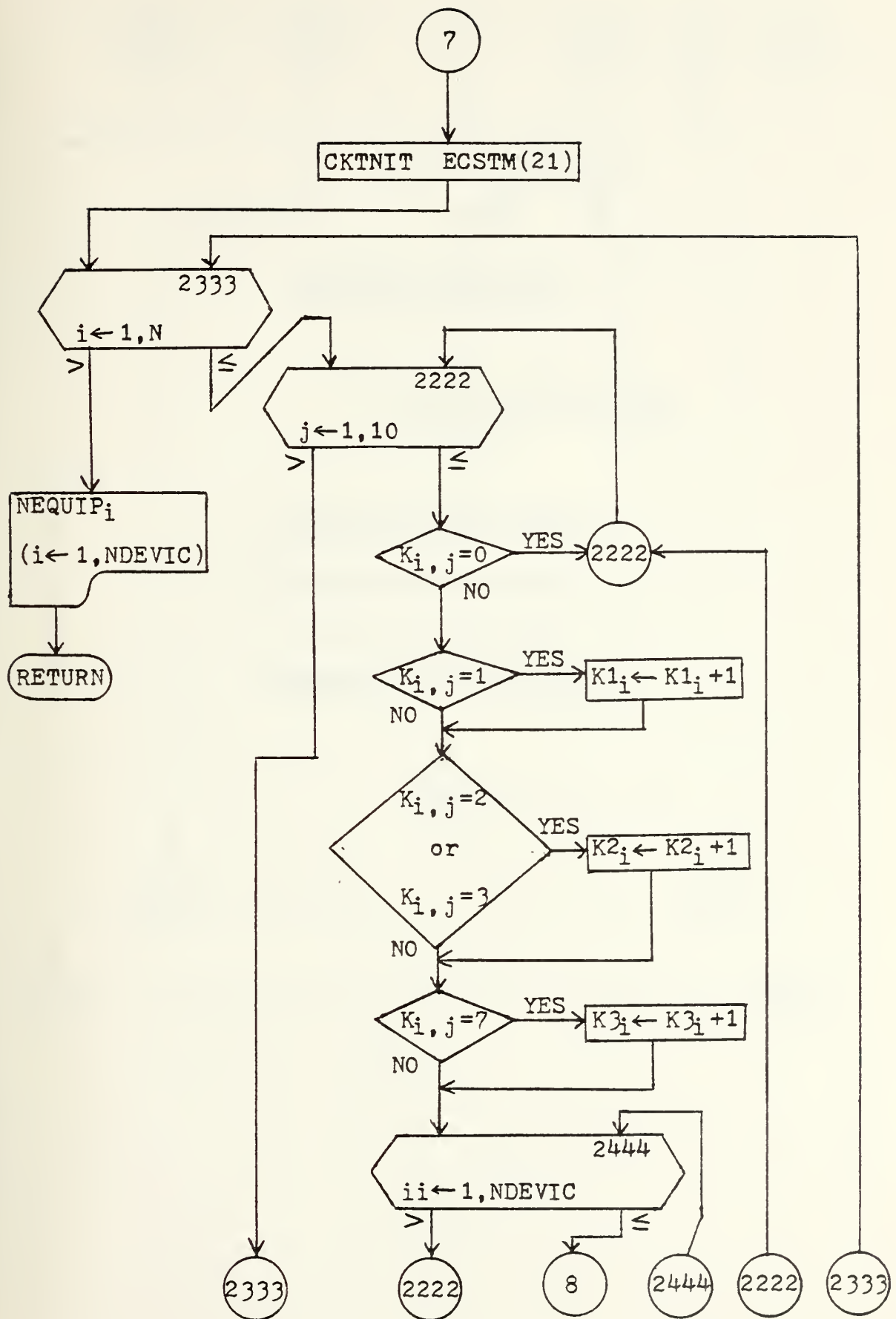


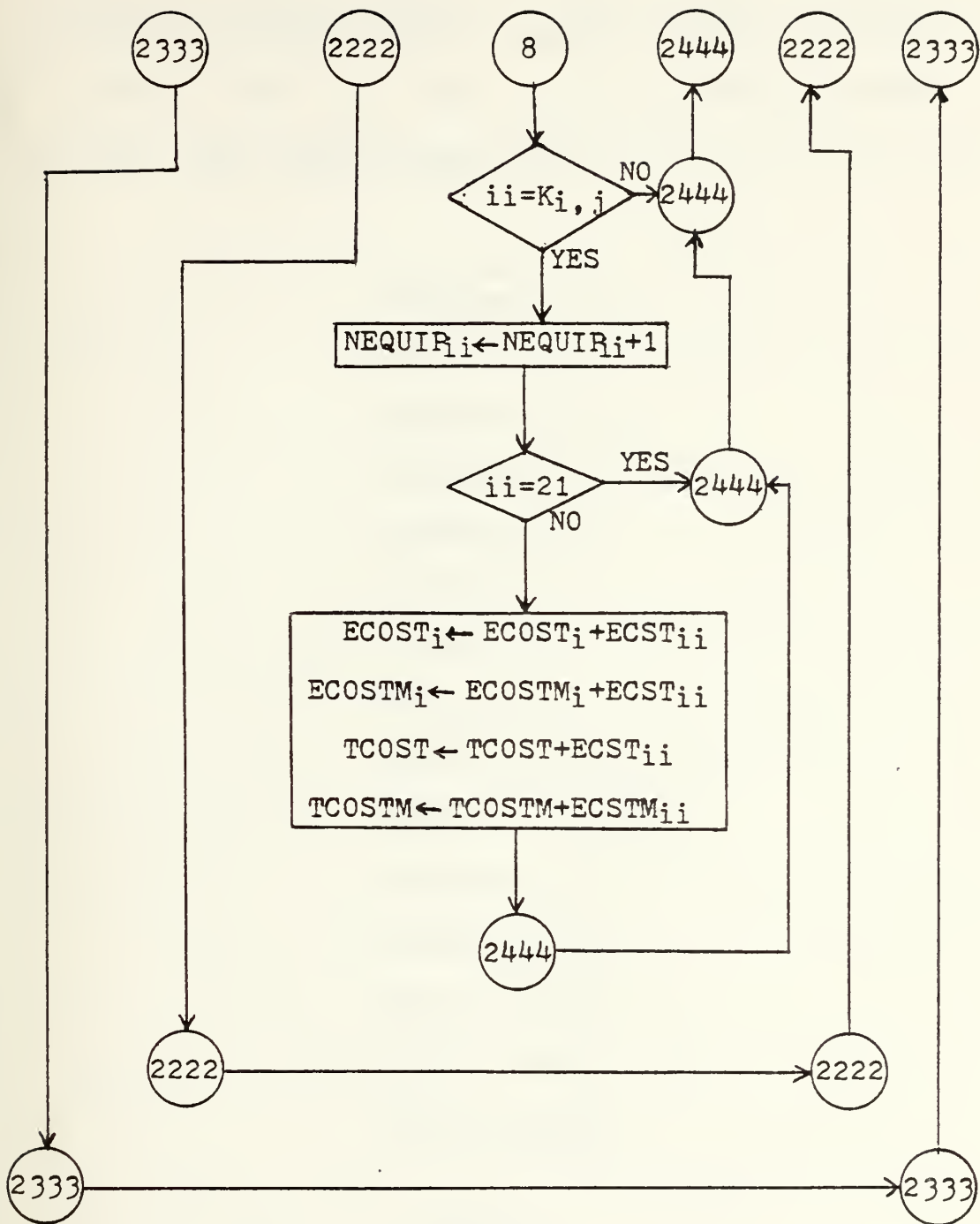




TSITE ($K_{i,j}$, $K1_i$, $K2_i$, $NEQUIP_i$, $ECOST_i$, $ECOSTM_i$,
 N , $TCOST$, $TCOSTM$, $NDEVIC$, $K3_i$, $CKTNIT$)



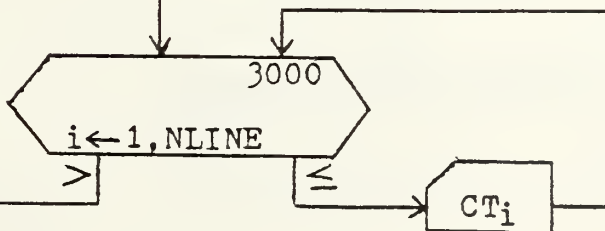


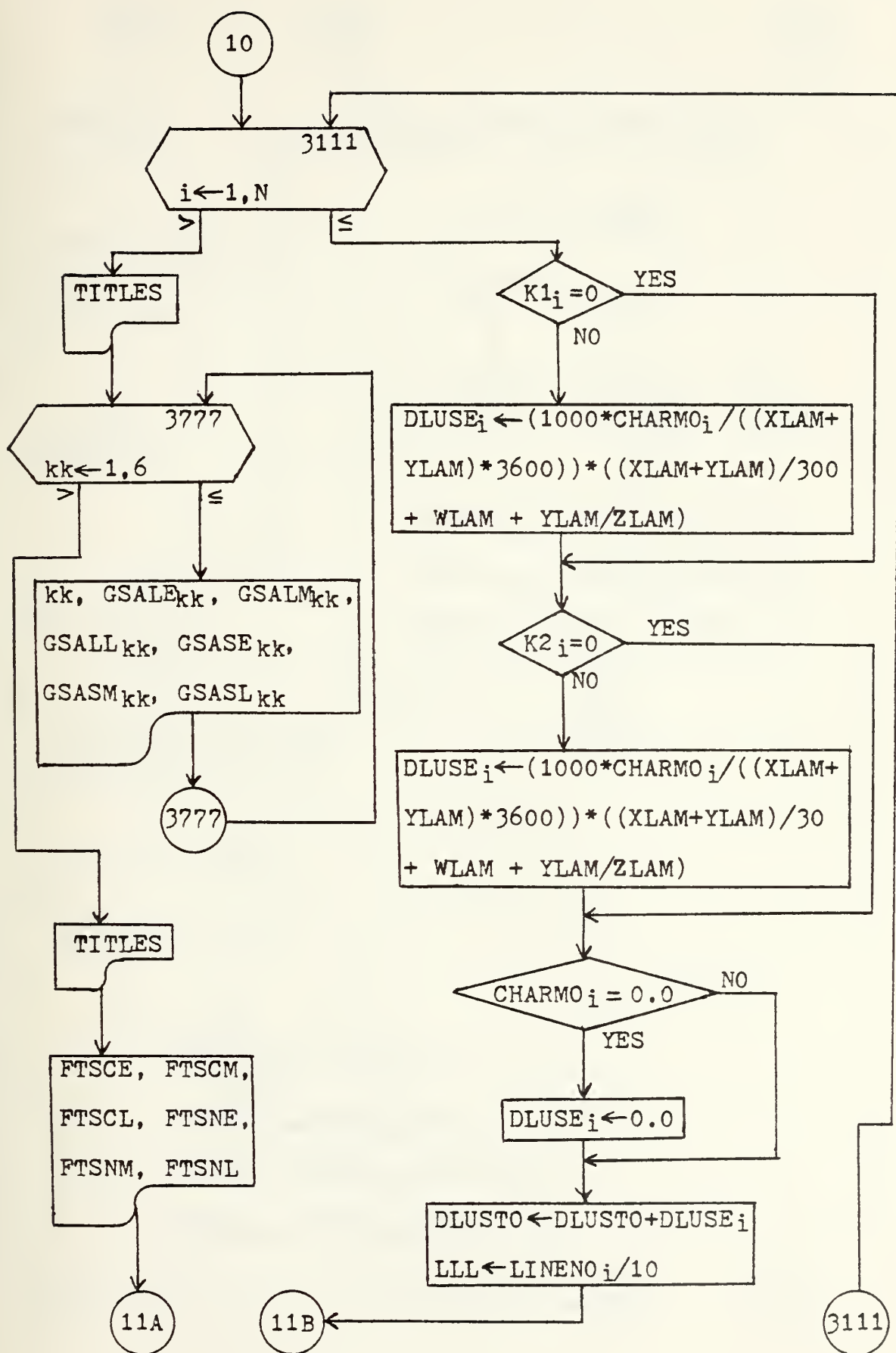


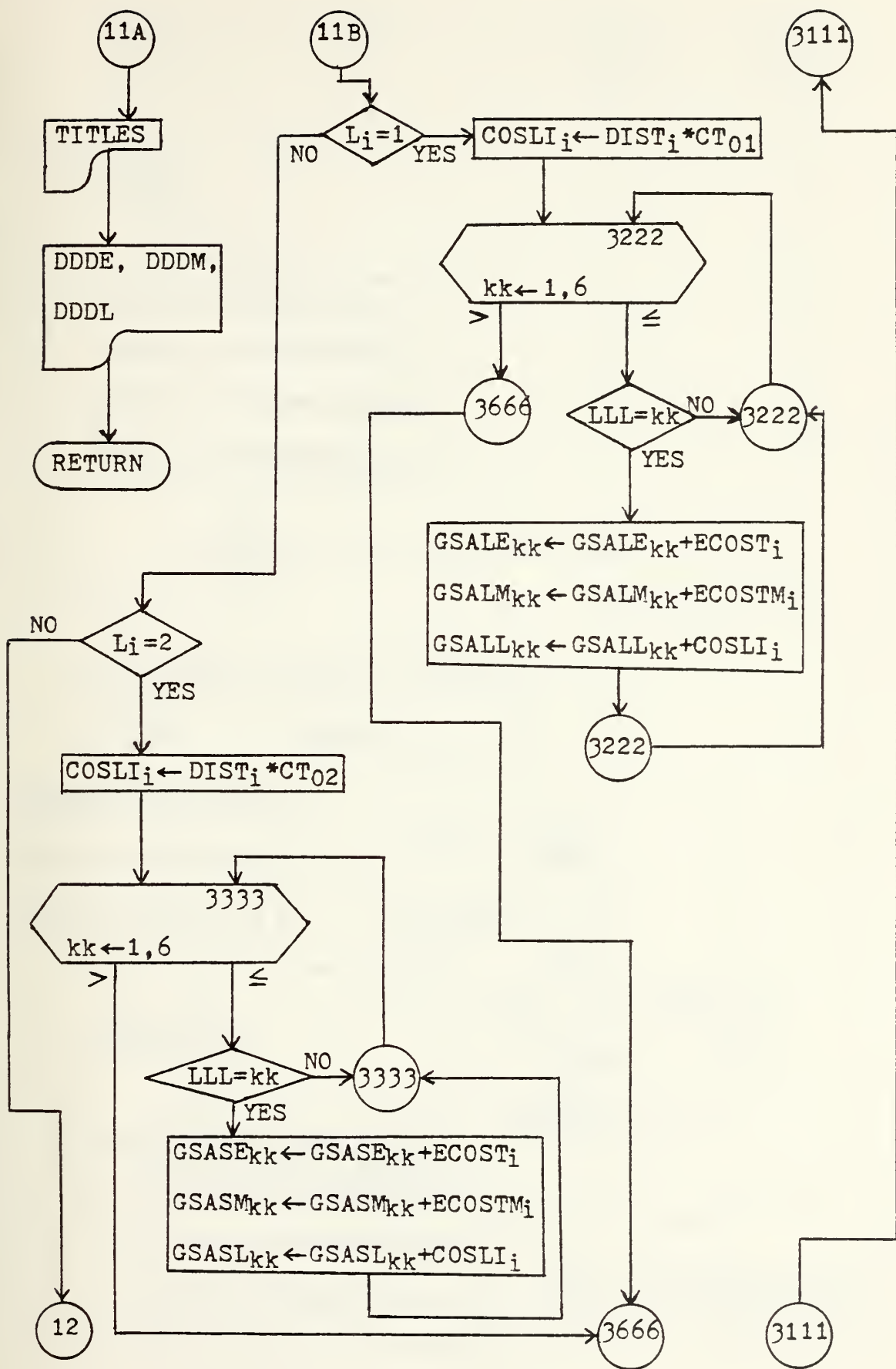
LINE (N, TCOSTM, COSLI_i, CHARMO_i, DLUSE_i, ECOSTM_i,
DIST_i, DLUSTO, K1_i, K2_i, Li, Ki,j, ECOST_i, LINENO_i,
XLAM, YLAM, ZLAM, WLAM, CKTNIT)

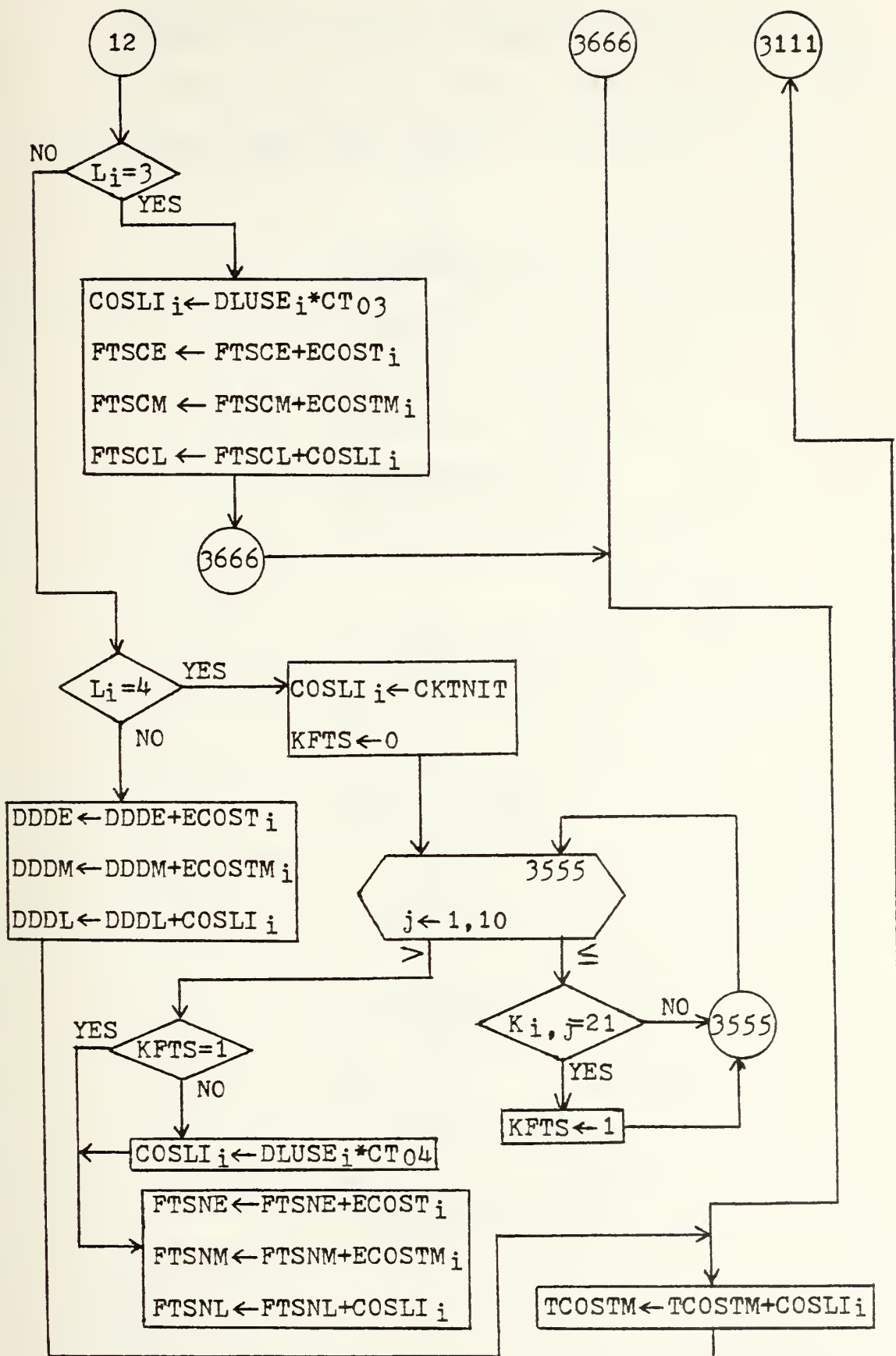
GSALE_i ← 0.0
GSALM_i ← 0.0
GSALL_i ← 0.0
GSASE_i ← 0.0
GSASM_i ← 0.0
GSASL_i ← 0.0
FTSCE ← 0.0
FTSCM ← 0.0
FTSCL ← 0.0
FTSNE ← 0.0
FTSNM ← 0.0
FTSNL ← 0.0
DDDE ← 0.0
DDDM ← 0.0
DDDL ← 0.0

NLINE

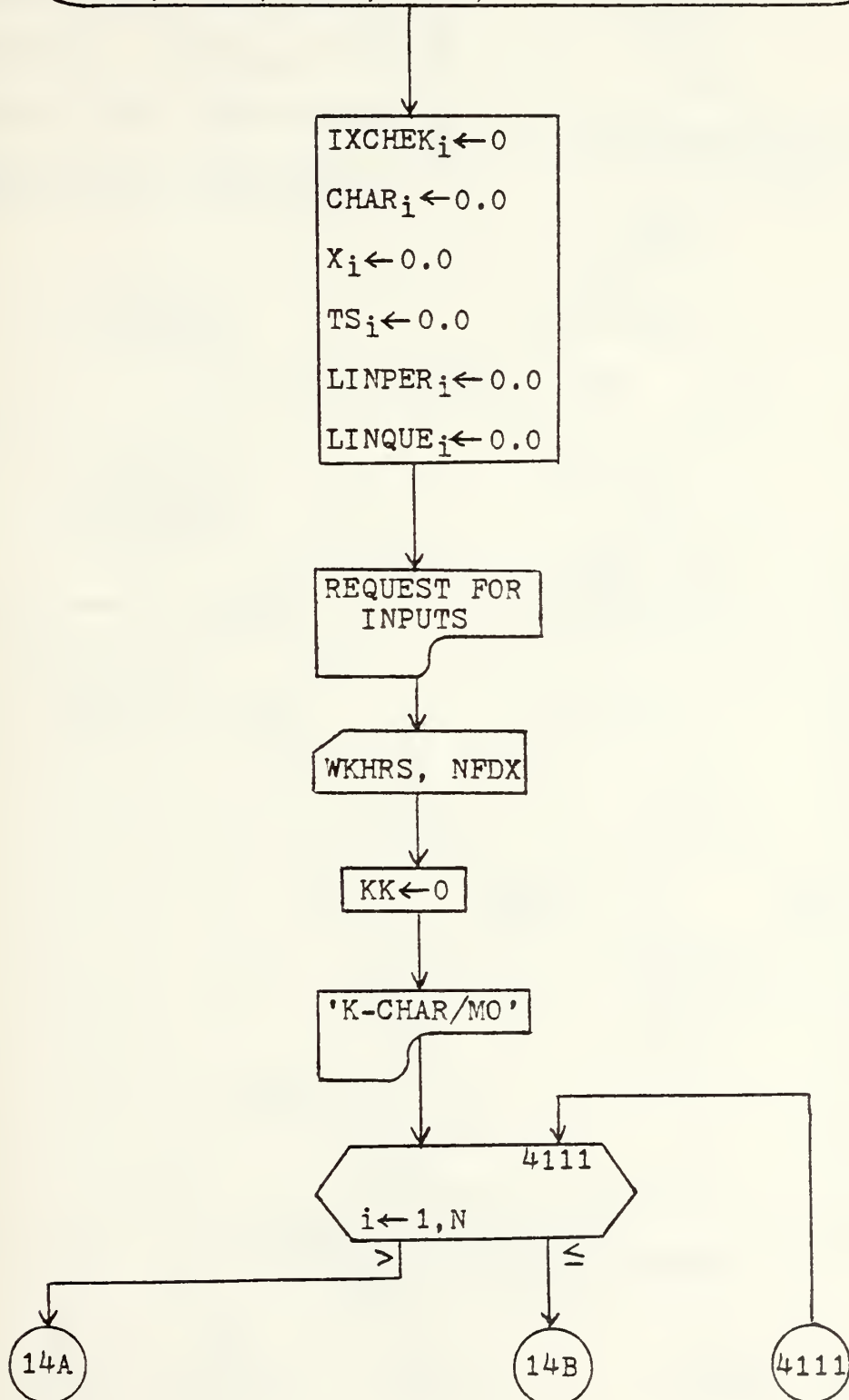


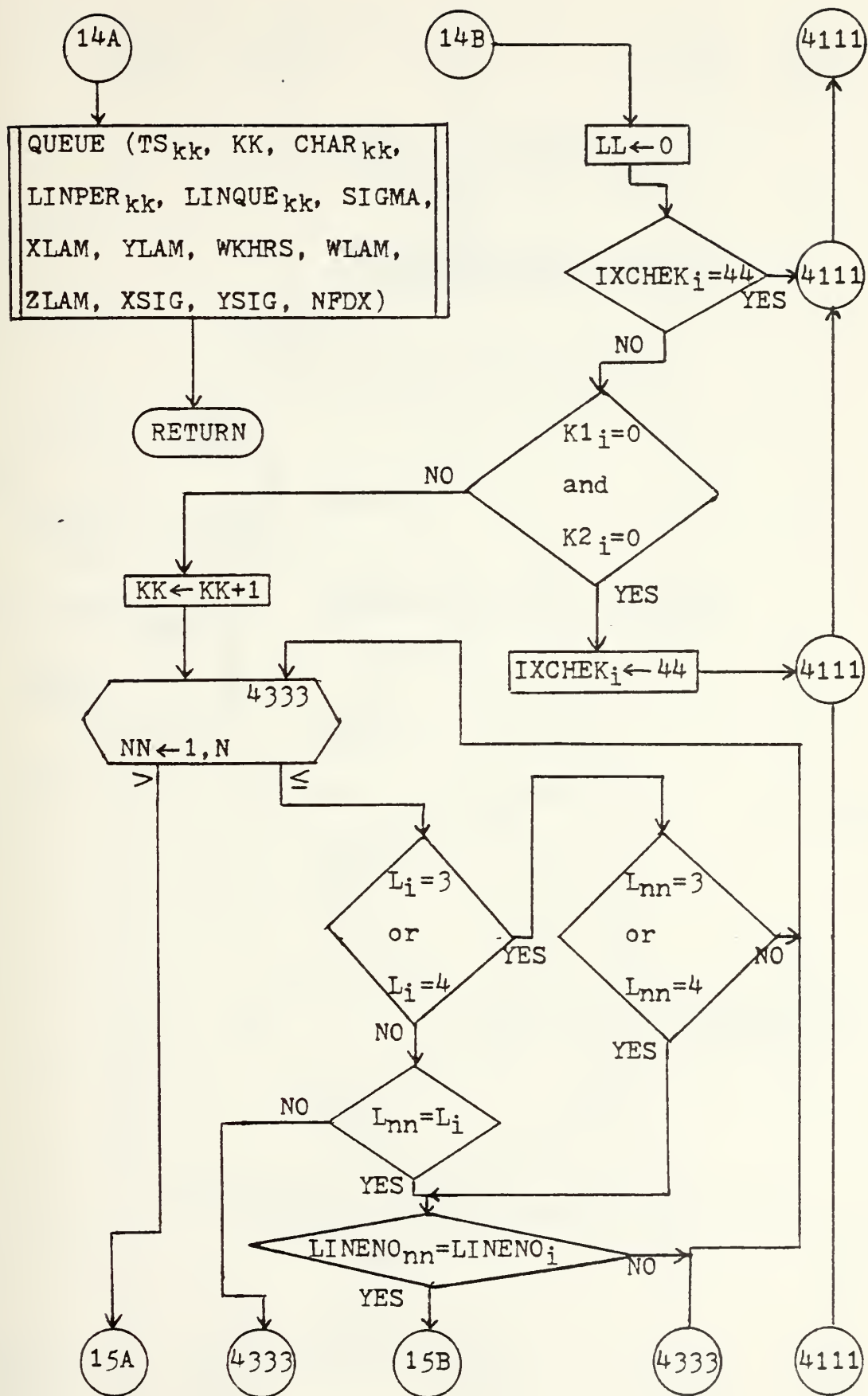


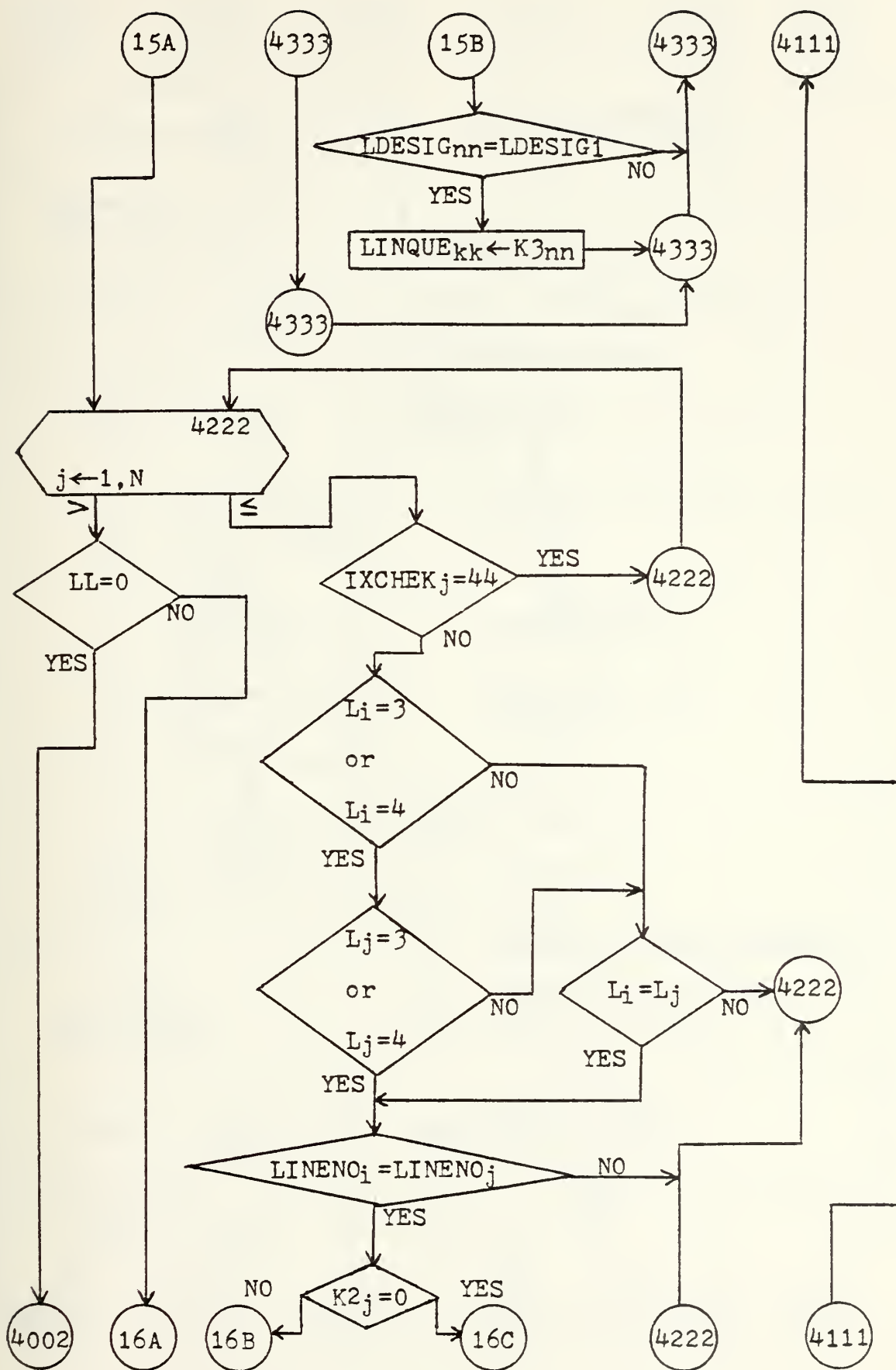


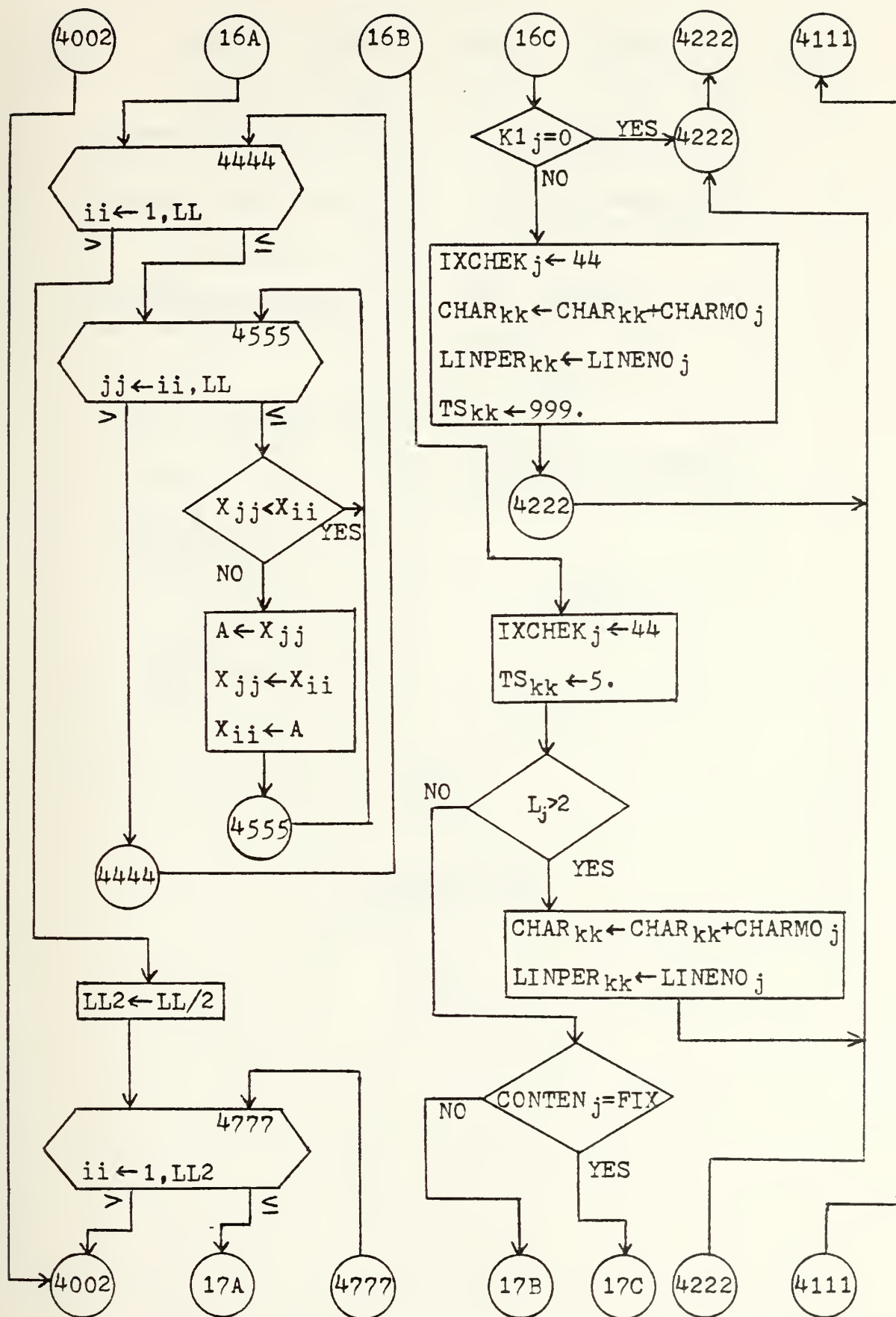


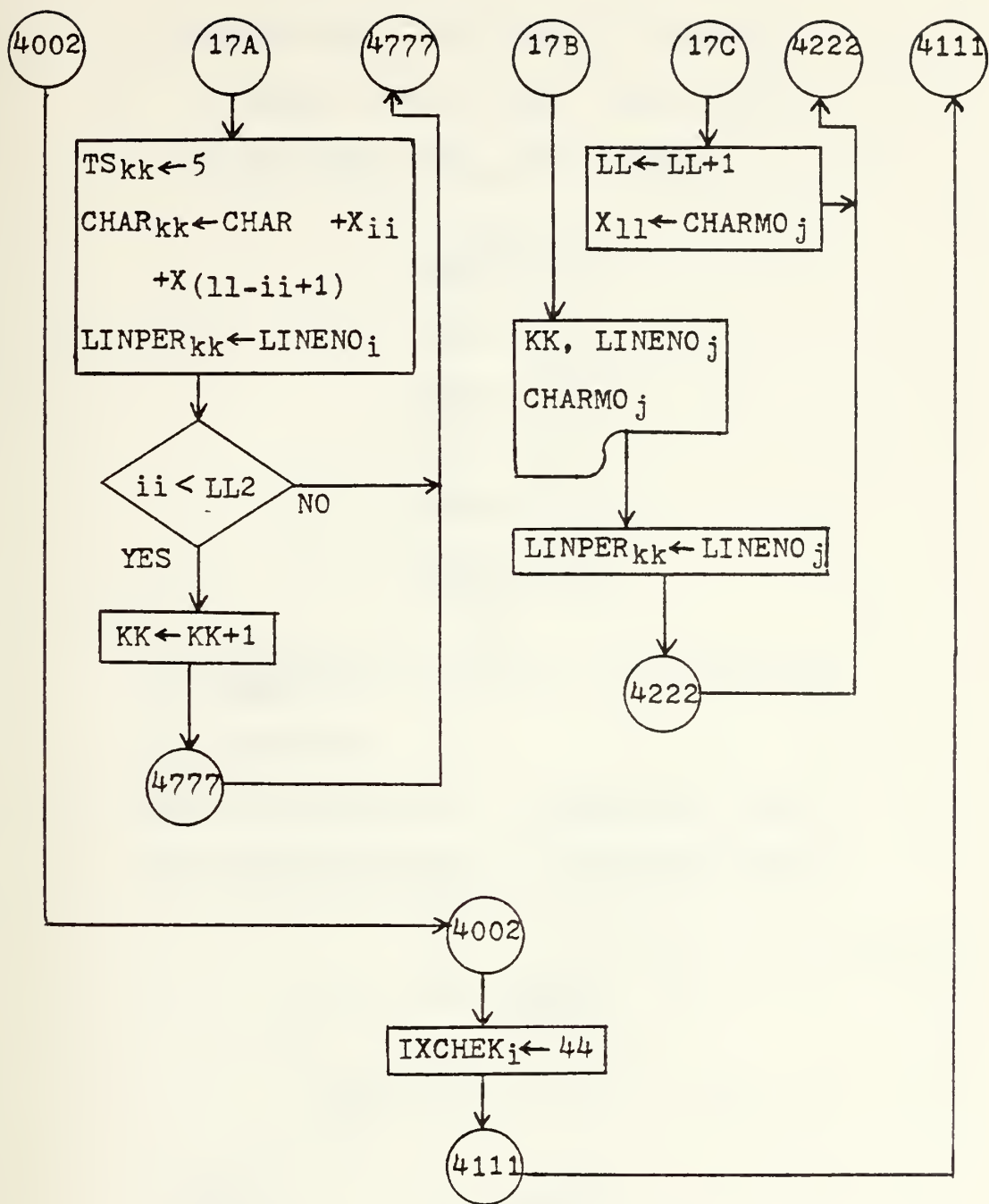
PERFOR (L_i , $LINENO_i$, $CHARMO_i$, N , $K1_i$, $K2_i$,
 $CONTEN_i$, FIX , $K3_i$, $LDESIG_i$, $XLAM$, $YLAM$,
 $ZLAM$, $WLAM$, $XSIG$, $YSIG$)







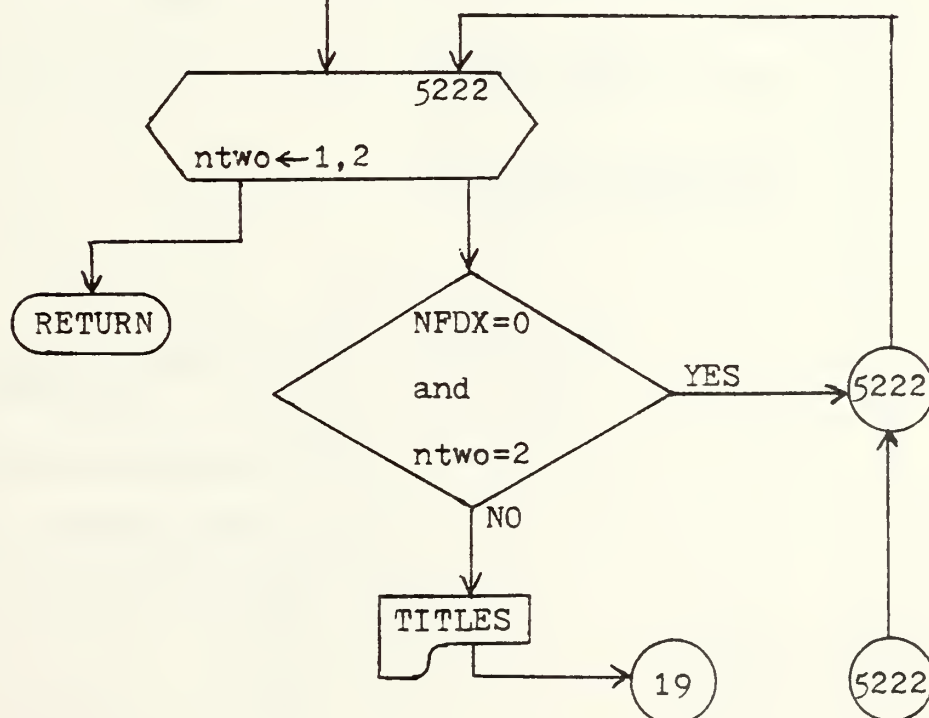


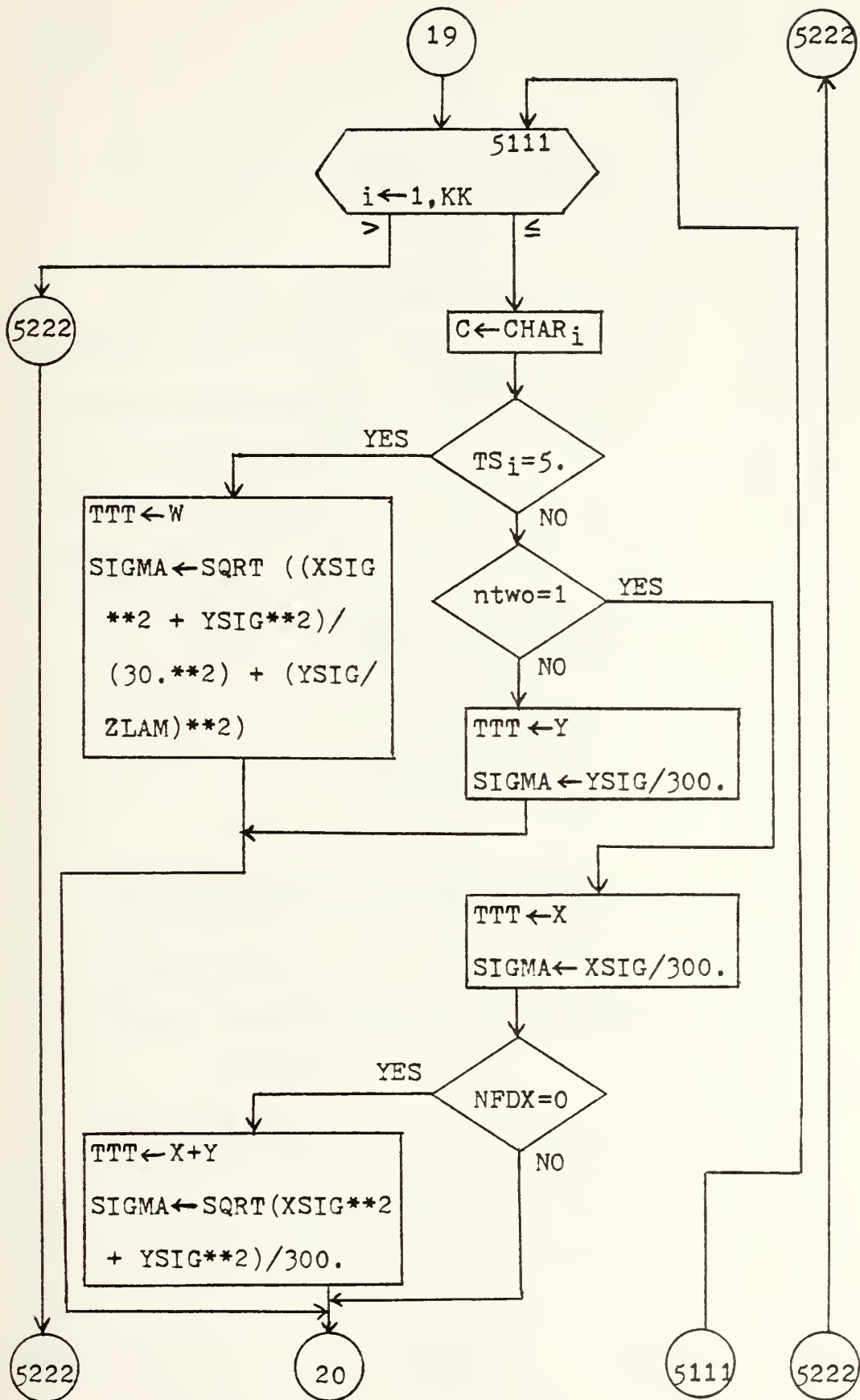


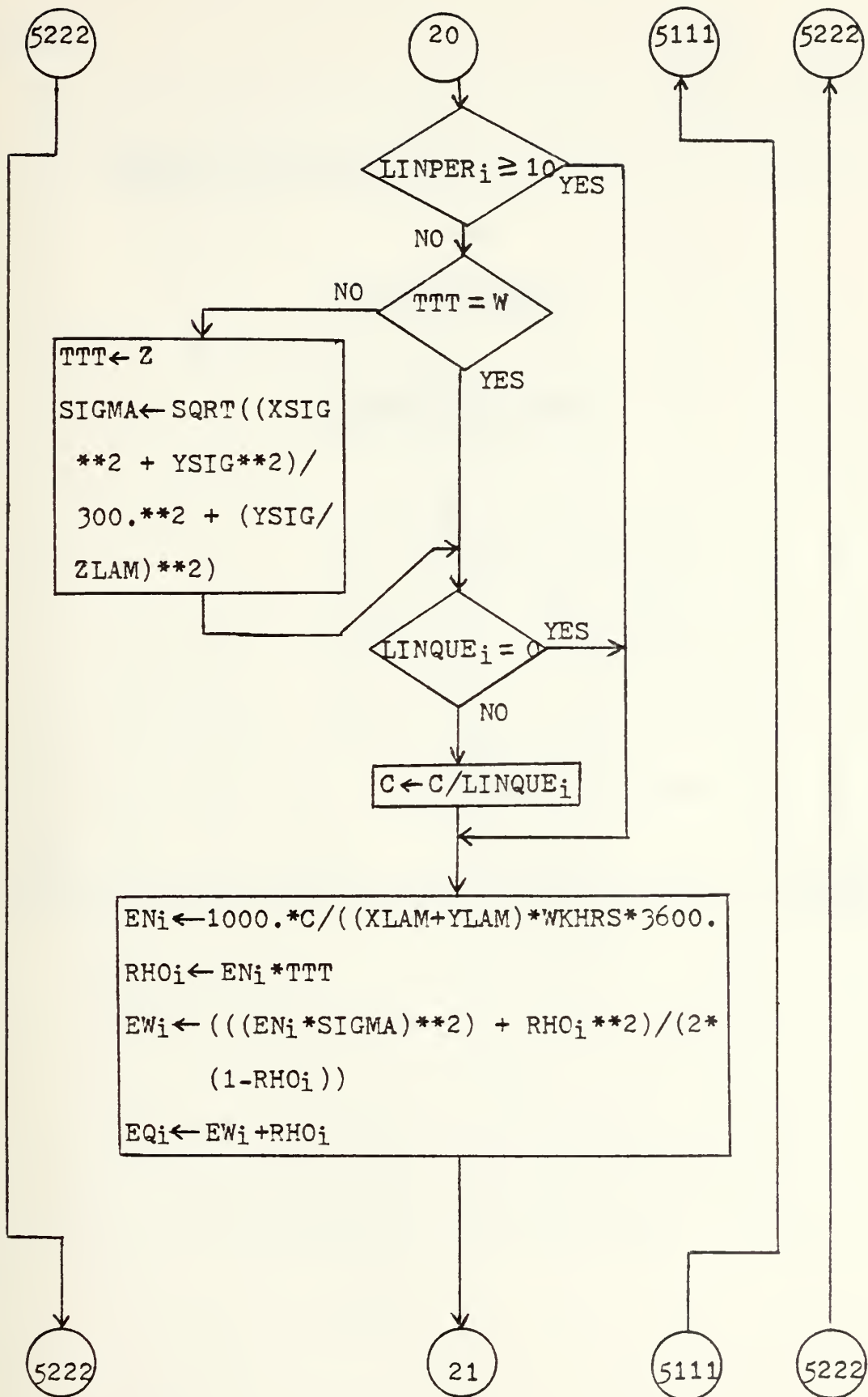
QUEUE (TS_{kk}, KK, CHAR_{kk}, LINPER_{kk},
LINQUE_{kk}, SIGMA, XLAM, YLAM, WKHRS,
WLAM, ZLAM, XSIG, YSIG, NFDX)

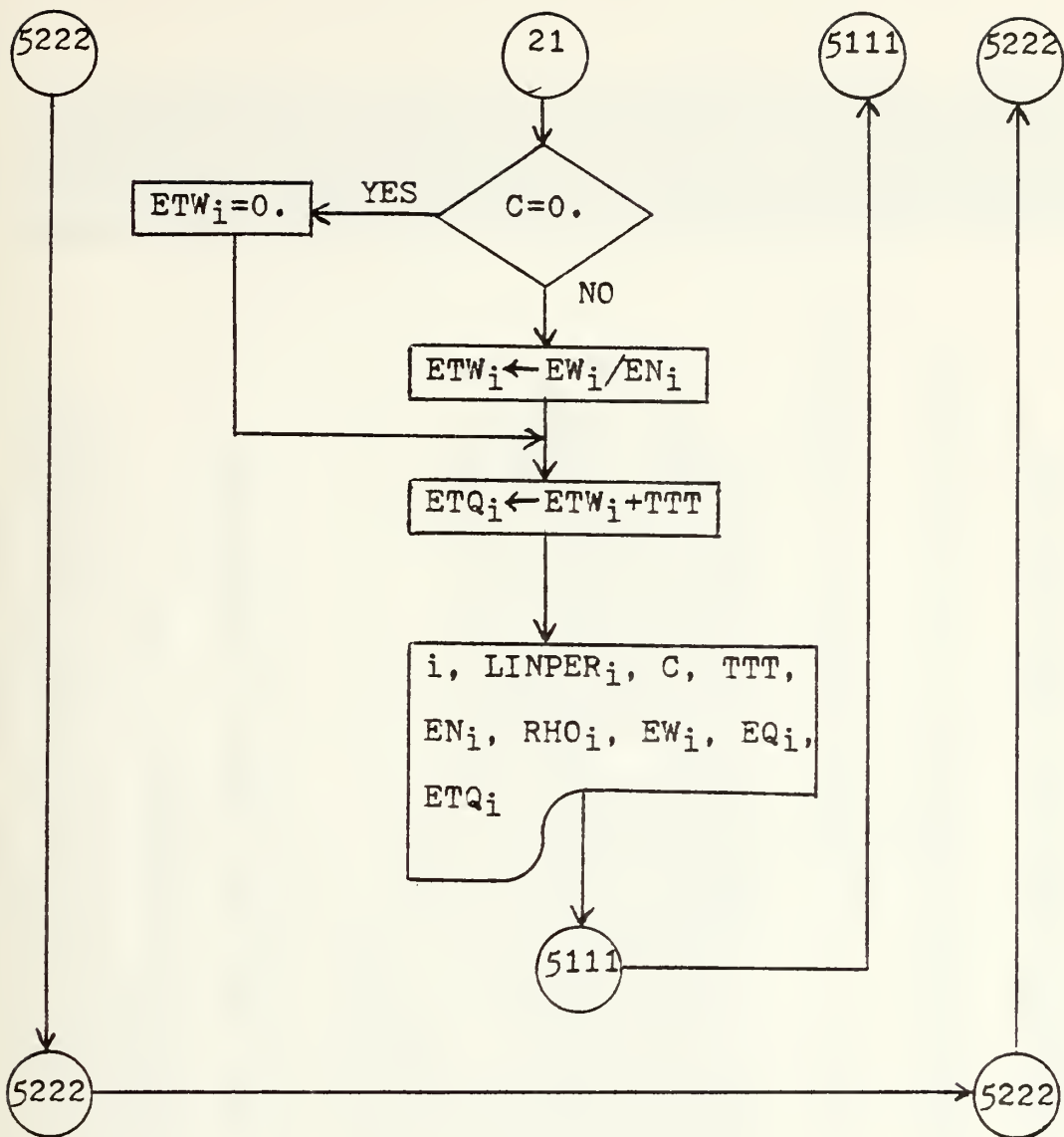
$\text{RHO}_i \leftarrow 0.0$
 $\text{EN}_i \leftarrow 0.0$
 $\text{EW}_i \leftarrow 0.0$
 $\text{EQ}_i \leftarrow 0.0$
 $\text{ETW}_i \leftarrow 0.0$
 $\text{ETQ}_i \leftarrow 0.0$

$X \leftarrow \text{XLAM}/300.$
 $Y \leftarrow \text{YLAM}/300.$
 $W \leftarrow (\text{XLAM} + \text{YLAM})/30. + \text{YLAM}/\text{ZLAM} + \text{WLAM}$
 $Z \leftarrow (\text{XLAM} + \text{YLAM})/300. + \text{YLAM}/\text{ZLAM} + \text{WLAM}$









APPENDIX F

VIIS COST AND PERFORMANCE PROGRAM LISTING

```

DIMENSION NQ(100),NOA(100),V(100),H(100),L(100),DIST(100),
IK(100,10),K1(100),K2(100),NEQUIP(25),ECOST(100),ECOSTM(100),
ICHARMO(100),COSLI(100),DLUSE(100),LDESIG(100),LINENO(100),
ICONTEN(100),TITLE(10),K3(100)
DATA K1/100*0/,K2/100*0/,NEQUIP/25*0/,ECOST/100*0.0/,
IECOSTM/100*0.0/,COSLI/100*0.0/,K3/100*0/

INPUT THE NUMBER OF DATA CARDS TO BE READ, THE CHARACTER
TO INDICATE TERMINALS IN CONTENTION, AND THE SYSTEM NAME.

READ (4,101) N,FIX,(TITLE(I),I=1,10)
FORMAT (13,A1,10A4)
WRITE (7,106) (TITLE(I),I=1,10)
FORMAT ('*****',10A4,'*****//')
FORMAT (3A5,2I2,' FTS-CONUS ',4F12.2)
FORMAT (3A5,2I2,' FTS-NONCO ',4F12.2)
FORMAT (3A5,2I2,5F12.2)
FORMAT (1X,A4,1X,A4,2I2,A4,1X,A1,4X,F6.0,F8.0,2F6.0,10I2)

READ IN THE DATA FOR EACH NODE IN THE NETWORK. FOR THOSE
LOCATIONS WITH MORE THAN ONE OFFICE OR HAVING SEVERAL TYPES
OF LINES, SEPARATE DATA CARDS ARE REQUIRED FOR EACH. DATA
TO BE READ IN INCLUDES THE NODE DESIGNATION, PREVIOUS NODE
IN THE NETWORK, LINE TYPE, LINE NUMBER, SPECIAL DESIGNATIONS
FOR LOCATIONS WITH MORE THAN ONE OFFICE, CONTENTION
CHARACTER IF REQUIRED, DISTANCE BETWEEN THIS NODE AND LAST
NODE, CHARACTERS PER MONTH SENT OR RECEIVED AT THE TERMINAL,
"V" AND "H" COORDINATES IF DISTANCES WERE NOT USED, AND
THE EQUIPMENT AT THE NODE AS A STRING OF TWO CHARACTER
NUMERIC CODES.

DO 1111 I=1,N
  READ (4,102) NO(I),NOA(I),L(I),LINENO(I),LDESIG(I),CONTEN(I),
  DIST(I),CHARMO(I),V(I),H(I),(K(I,J),J=1,10)
  1 CCNTINUE
  CALL MILE (NO,NOA,V,H,L,DIST,DIST,DIST2,N)
  CALL TSITE (K,K1,K2,NEQUIP,ECOST,ECOSTM,N,TCOST,TCOSTM,NDEVIC,
  1 K3,CKINIT)

INPUT THE MEAN NUMBER OF CHARACTERS PER FRAME, ITS STANDARD
DEVIATION, THE MEAN NUMBER OF CHARACTERS TYPED IN, ITS
STANDARD DEVIATION, THE MEAN TYPING SPEED, AND THE MEAN
COMPUTER TURNAROUND TIMES.

```



```

1002 WRITE (6,110)
110 FORMAT (:,INPUT THE MEAN CHARACTERS PER FRAME')
    READ (5,111) XLAM
    IF (XLAM.LT.0.0) GO TO 1001
111 FORMAT (F10.0)
    WRITE (6,112)
112 FORMAT (:,INPUT THE STANDARD DEVIATION')
    READ (5,111) XSIG
    WRITE (6,113)
113 FORMAT (:,INPUT MEAN CHARACTERS TYPED-IN PER TRANSACTION')
    READ (5,111) YLAM
    WRITE (6,114)
114 FORMAT (:,INPUT THE STANDARD DEVIATION')
    READ (5,111) YSIG
    WRITE (6,115)
115 FORMAT (:,INPUT THE MEAN TYPING SPEED IN CHAR PER SECOND')
    READ (5,111) ZLAM
    WRITE (6,116)
116 FORMAT (:,INPUT THE MEAN ACCESS TIME PER TRANSACTION')
    READ (5,111) WLAM
    CALL LINE (N,TCOSTM,COSLI,CHARMO,DLUSE,ECOSTM,DIST,DLUSTC,
    1K1,K2,L,K,ECOST,LINENO,XLAM,YLAM,ZLAM,WLAM,CKINIT)

    OUTPUT THE LEASED LINE TOTAL DISTANCES (DEDICATED AND
    SHARED), THE TOTAL ONE-TIME AND MONTHLY RECURRING COSTS,
    AND THE TOTAL CONNECT HOURS.

    WRITE (7,104) DTOT,DTOT2,TCOST,TCOSTM,DLUSTC
104 FORMAT (:,DTOT =,F10.2//,DTOT2 =,F10.2//1X,
    1,TCOST =,F10.2//,TCOSTM =,F10.2//,DLUSTO =,F10.2/)

    OUTPUT THE NODE DESIGNATION, THE PREVIOUS NCDES DESIGNATION,
    ANY SPECIAL DESIGNATION, THE LINE TYPE AND NUMBER, DISTANCE,
    THE CONNECT HOURS PER MONTH, THE MONTHLY EQUIPMENT COSTS,
    THE ONE-TIME EQUIPMENT COSTS, AND THE LINE COSTS FOR EACH
    LOCATION.

    WRITE (7,107)
    FORMAT (:,NUDE',4X,'DESIG',1X,'LINE',5X,'MILAGE',4X,'CONNECT',
    19X,'EQUIPMENT COST',6X,'LINE COST',/16X,'NO.',16X,'HOURS',
    16X,'RECURRING',3X,'ONE-TIME',/)
    DO 1444 I=1,N
    IF (DIST(I).LT.0.0) GO TO 1100
    WRITE (7,103) NO(I),NOA(I),LDESIG(I),L(I),LINENO(I),DIST(I),
    1 DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)
    GO TO 1444

```


VIIIS COST AND PERFORMANCE PROGRAM LISTING

CONT INUED

```

1100 IF (DIST(I).EQ.-10.0) WRITE (7,108) NO(I),NOA(I),LDESIG(I),
1 L(I),LINENO(I),DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)
1 IF (DIST(I).EQ.-20.0) WRITE (7,109) NO(I),NOA(I),LDESIG(I),
1 L(I),LINENO(I),DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)
1444 CONTINUE
CALL PERFOR (L,LINENO,CHARMO,N,K1,K2,CONTEN,FIX,K3,LDESIG,
1XLAM,YLAM,ZLAM,WLAM,XSIG,YSIG)
1001 STOP
END

```

MSI000910
MSI000920
MSI000930
MSI000940
MSI000950
MSI000960
MSI000970
MSI000980
MSI000990

```

SUBROUTINE MILE (NO,NOA,V,H,L,DIST,DTOT,DTCT2,N)
DIMENSION NU(100),NDA(100),L(100),V(100),H(100),DIST(100)

CALCULATE DISTANCES BETWEEN TERMINAL LOCATIONS USING
TELEPHONE COMPANY "V" AND "H" COORDINATES OR BY READING
IN DISTANCES. FTS CONUS LINES AND FTS NON-CONUS LINES ARE
ASSIGNED SPECIAL VALUES FOR EASE OF IDENTIFICATION.

```

MIL000010
MIL000020
MIL000030
MIL000040
MIL000050
MIL000060
MIL000070
MIL000080
MIL000090
MIL000100
MIL000110
MIL000120
MIL000130
MIL000140
MIL000150
MIL000160
MIL000170
MIL000180
MIL000190
MIL000200
MIL000210
MIL000220
MIL000230
MIL000240
MIL000250
MIL000260
MIL000270
MIL000280
MIL000290
MIL000300
MIL000310
MIL000320
MIL000330
MIL000340
MIL000350

```

DTOT=0.0
DTOT2=0.0
DO 1222 I=1,N
IF (L(I).EQ.3) GO TO 1000
IF (L(I).EQ.4) GO TO 1001
IF (DIST(I).NE.0.0) GO TO 1002
IF (V(I).EQ.0.0.AND.H(I).EQ.0.0) GO TO 1222
DO 1333 J=1,N
IF (V(J).EQ.0.0.AND.H(J).EQ.0.0) GO TO 1333
IF (NO(J).NE.NOA(I)) GO TO 1333
X=(V(I)-V(J))*(V(I)-V(J))+(H(I)-H(J))*(H(I)-H(J))
DIST(I)=SQRT(X/10.0)
CONTINUE
IF (L(I).EQ.2) GO TO 1999

```

MIL000010
MIL000020
MIL000030
MIL000040
MIL000050
MIL000060
MIL000070
MIL000080
MIL000090
MIL000100
MIL000110
MIL000120
MIL000130
MIL000140
MIL000150
MIL000160
MIL000170
MIL000180
MIL000190
MIL000200
MIL000210
MIL000220
MIL000230
MIL000240
MIL000250
MIL000260
MIL000270
MIL000280
MIL000290
MIL000300
MIL000310
MIL000320
MIL000330
MIL000340
MIL000350

DETERMINE TOTAL DISTANCE OF LEASED LINES.

```

1002 DTOT=DTOT+DIST(I)
GO TO 1222
1999 DTOT2=DTOT2+DIST(I)
GO TO 1222
1000 DIST(I)=-10.0
GO TO 1222
1001 DIST(I)=-20.
1222 CCNTINUE
RETURN
END

```

MIL000010
MIL000020
MIL000030
MIL000040
MIL000050
MIL000060
MIL000070
MIL000080
MIL000090
MIL000100
MIL000110
MIL000120
MIL000130
MIL000140
MIL000150
MIL000160
MIL000170
MIL000180
MIL000190
MIL000200
MIL000210
MIL000220
MIL000230
MIL000240
MIL000250
MIL000260
MIL000270
MIL000280
MIL000290
MIL000300
MIL000310
MIL000320
MIL000330
MIL000340
MIL000350

VIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

```

2555 WRITE (7,122)
122  FORMAT (1, LEASED EQUIPMENT.)
      DO 2777 I=1,NDEVIC
119  READ (1,119) ECST(I), ECSTM(I)
2777  FORMAT (20X,2F10.0)
2666  CONTINUE
      CKTNIT=ECSTM(21)
C
C      CALCULATE THE NUMBER OF CRT'S AND TELEPRINTERS AT EACH LOCATION.
C      CALCULATE THE TOTAL NUMBER OF EACH TYPE OF EQUIPMENT.
C      CALCULATE THE ONE-TIME AND RECURRING EQUIPMENT COSTS FOR
C      EACH LOCATION. DETERMINE THE TOTAL ONE-TIME AND RECURRING
C      EQUIPMENT COSTS FOR THE NETWORK.
      DO 2222 I=1,N
      DO 2333 J=1,10
      IF (K(I,J).EQ.0) GO TO 2333
      IF (K(I,J).EQ.1) K1(I)=K1(I)+1
      IF (K(I,J).EQ.2.OR.K(I,J).EQ.3) K2(I)=K2(I)+1
      DO 2444 I1=1,NDEVIC
      IF (I1.NE.K(I,J)) GO TO 2444
      NEQUIP(I1)=NEQUIP(I1)+1
      ECOST(I1)=ECOST(I1)+ECST(I1)
      ECOSTM(I1)=ECOSTM(I1)+ECSTM(I1)
      TCOST=TCOST+ECST(I1)
      TCOSTM=TCOSTM+ECSTM(I1)
      CONTINUE
2444  CONTINUE
2333  CONTINUE
2222  CONTINUE
C
C      OUTPUT THE TOTAL NUMBER OF EACH TYPE OF EQUIPMENT.
      WRITE (7,105) (NEQUIP(I2),I2=1,NDEVIC)
105  FORMAT (/,' CRT ',13//,' TPTR ',13//,' TPTR/C ',
113//,' PTR ',13//,' HDCPY ',13//,' FDMCSS ',13//,
119  'DAA ',13//,' S2400M ',13//,' S4800M ',13//,' S7200M ',13//,
119  'S9600M ',13//,' A300M ',13//,' MSD ',13//,' ADD ',13//,
119  'TDMCSS ',13//,' FDMCNL ',13//,' TDMCNL ',13//,' C2COND ',13//,
119  'GSATER ',13//,' LCLTEL ',13//,' FTSNIC ',13//)
      RETURN
      END
C
C      SLBRoutine LINE (N,TCOSTM,COSLI,CHARMO,DLUSE,ECOSTM,DIST,DLUSTO,
1K1,K2,L,K,ECOST,LINENO,XLAM,YLAM,ZLAM,WLAM,CKTNIT)
DIMENSION COSLI(100),CHARMO(100),DLUSE(100),ECOSTM(100),CT(10),

```

TSI00460
TSI00470
TSI00480
TSI00490
TSI00500
TSI00510
TSI00511
TSI00520
TSI00530
TSI00540
TSI00550
TSI00560
TSI00570
TSI00580
TSI00590
TSI00600
TSI00610
TSI00620
TSI00630
TSI00640
TSI00650
TSI00660
TSI00670
TSI00680
TSI00690
TSI00700
TSI00710
TSI00720
TSI00730
TSI00740
TSI00750
TSI00760
TSI00770
TSI00780
TSI00790
TSI00800
TSI00810
TSI00820
TSI00830
TSI00840
TSI00850

LIN00010
LIN00020
LIN00030

87

VIIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

C DETERMINE THE COST FOR EQUIPMENT (ONE-TIME AND RECURRING)
C AND LINE COSTS FOR EACH GSA DEDICATED LINE.

COSLI(I)=DIST(I)*CT(01)

DO 3222 KK=1,6

IF (LLL.NE.KK) GO TO 3222

GSALM(KK)=GSALM(KK)+ECOSTM(I)

GSALL(KK)=GSALL(KK)+COSLI(I)

CONTINUE

3222

GO TO 3666

IF (L(I).NE.02) GO TO 3002

3001

C DETERMINE THE COST OF THE GSA-LEASED/SHARED LINES.

C DETERMINE THE COST FOR EQUIPMENT (ONE-TIME AND RECURRING)

C AND LINE COSTS FOR EACH GSA SHARED LINE.

COSLI(I)=DIST(I)*CT(02)

DO 3333 KK=1,6

IF (LLL.NE.KK) GO TO 3333

GSASE(KK)=GSASE(KK)+ECOST(I)

GSASM(KK)=GSASM(KK)+ECOSTM(I)

GSASL(KK)=GSASL(KK)+COSLI(I)

CONTINUE

GO TO 3666

IF (L(I).NE.03) GO TO 3003

3002

C DETERMINE THE LINE COSTS FOR THE FTS-CONUS LINES.

C DETERMINE THE EQUIPMENT COSTS AND LINE COSTS OF THE FTS NETWORK.

COSLI(I)=DLUSE(I)*CT(03)

FTSCE=FTSCE+ECOST(I)

FTSCM=FTSCM+ECOSTM(I)

FTSCL=FTSCL+COSLI(I)

GO TO 3666

IF (L(I).NE.04) GO TO 3004

3003

C DETERMINE THE LINE COSTS (CONNECT TIME CHARGES) FOR THE FTS

C NCN-CONUS NETWORK. DETERMINE THE EQUIPMENT COSTS ALSO.

COSLI(I)=CKTNIT

KFTS=0

DO 3555 J=1,10

IF (K(I,J).EQ.21) KFTS=1

CONTINUE

3555

IF (KFTS.NE.1) COSLI(I)=DLUSE(I)*CT(04)

LIN00500
LIN00510
LIN00520
LIN00530
LIN00540
LIN00550
LIN00560
LIN00570
LIN00580
LIN00590
LIN00600
LIN00610
LIN00620
LIN00630
LIN00640
LIN00650
LIN00660
LIN00670
LIN00680
LIN00690
LIN00700
LIN00710
LIN00720
LIN00730
LIN00740
LIN00750
LIN00760
LIN00770
LIN00780
LIN00790
LIN00800
LIN00810
LIN00820
LIN00830
LIN00840
LIN00850
LIN00860
LIN00870
LIN00880
LIN00890
LIN00900
LIN00910
LIN00920
LIN00930
LIN00940
LIN00950

VIIIS COST AND PERFORMANCE PROGRAM LISTING

CONT INUED

[illegible]

VIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

```

SUBROUTINE PERFOR (L,LINENO,CHARMO,N,K1,K2,CONTEN,FIX,K3,LDESIG,
1XLAM,YLAM,ZLAM,WLAM,XSIG,YSIG)
DIMENSION L(100),LINENO(100),CHARMO(100),CHAR(30),IXCHEK(100),
1K1(100),K2(100),CCNTEN(100),X(10),TS(30),LINPER(30),K3(100),
1LINQUE(30),LDESIG(100)
DATA IXCHEK/100*0/,CHAR/30*0./,X/10*0./,TS/30*0./,LINPER/30*0/,
1LINQUE/30*0/

C
C
C      READ IN THE NUMBER OF WORKING HOURS PER MONTH.
C
104      WRITE (6,104)
      FORMAT (1,INPUT THE NUMBER OF WORKING HOURS PER MONTH)
105      READ (5,105) WKHRS
      FCRMAT (F10.0)

C
C
C      SELECT FULL OR HALF DUPLEX LINES.
C
106      WRITE (6,106)
      FORMAT (1,INPUT 0 FOR HALF DUPLEX LINES)
107      READ (5,107) NFDX
      FORMAT (11)

C
C
C      INITIALIZE THE NUMBER OF INDEPENDENT SUB-NETWORKS.
      KK=0
      WRITE (7,102)
      DO 4111 I=1,N
      LL=0

C
C
C      IF THE FLAG (IXCHEK) IS 44, THE NODE HAS ALREADY BEEN
      CCNSIDERED.
      IF (IXCHEK(I).EQ.44) GO TO 4111

C
C
C      IF THERE ARE NO TERMINALS AT THIS LOCATION, ASSIGN THE
      FLAG A VALUE OF 44 AND CONTINUE.
      IF (K1(I).EQ.0.AND.K2(I).EQ.0) GO TO 4002

C
C
C      THERE ARE TERMINALS AND THEY HAVE NOT BEEN PREVIOUSLY INCLUDED.
      INCREMENT THE SUB-NETWORK NUMBER AND CONTINUE.
      KK=KK+1
      DO 4333 NN=1,N

C
C
C      CCMPARE LINE TYPES, NUMBERS, AND DESIGNATIONS TO INSURE

```

PER00010
 PER00020
 PER00030
 PER00040
 PER00050
 PER00060
 PER00070
 PER00080
 PER00090
 PER00100
 PER00110
 PER00120
 PER00130
 PER00140
 PER00150
 PER00160
 PER00170
 PER00180
 PER00190
 PER00200
 PER00210
 PER00220
 PER00230
 PER00240
 PER00250
 PER00260
 PER00270
 PER00280
 PER00290
 PER00300
 PER00310
 PER00320
 PER00330
 PER00340
 PER00350
 PER00360
 PER00370
 PER00380
 PER00390
 PER00400
 PER00410
 PER00420
 PER00430
 PER00440
 PER00450
 PER00460

VIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

```

C      PRCPER CORRESPONDENCE.  LINE TYPE 3 AND 4 ARE CONSIDERED
C      EQUIVALENT FOR PERFORMANCE CALCULATIONS.
C
C      IF (L(I).EQ.3.OR.L(I).EQ.4) GO TO 4010
C      IF (L(NN).EQ.L(I)) GO TO 4011
C      GO TO 4333
4010  IF (L(NN).EQ.3.OR.L(NN).EQ.4) GO TO 4011
C      GO TO 4333
4011  IF (LINENO(NN).NE.LINENO(I)) GO TO 4333
C      IF (LDESIG(NN).NE.LDESIG(I)) GO TO 4333
C
C      TRANSFER THE VALUE FOR THE NUMBER OF DATA ACCESS ARRANGEMENTS
C      AT WASHINGTON FOR THIS LINE NUMBER.
C      LINQUE(KK)=K3(NN)
C      CONTINUE
4333
C      CCMPARE LINE TYPES AND NUMBERS FOR PROPER CORRESPONDENCE.
C      LINE TYPES 3 AND 4 ARE EQUIVALENT.
C
C      DO 4222 J=1,N
C      IF (IXCHEK(J).EQ.44) GO TO 4222
C      IF (L(I).EQ.3.OR.L(I).EQ.4) GO TO 4007
C      GO TO 4004
4007  IF (L(J).EQ.3.OR.L(J).EQ.4) GO TO 4008
4004  IF (L(I).NE.L(J)) GO TO 4222
4008  IF (LINENO(I).NE.LINENO(J)) GO TO 4222
C
C      CHECK FOR CRT OR TELEPRINTER TERMINALS.
C
C      IF (K2(J).NE.0) GO TO 4001
C      IF (K1(J).EQ.0) GO TO 4222
C
C      ASSIGN THE FLAG VALUE, SUM THE CHARACTERS ON THIS SUB-NETWORK,
C      TRANSFER THE LINE NUMBER VALUE, AND ASSIGN A VALUE FOR TS
C      REPRESENTING HIGH SPEED CRT TERMINALS.
C
C      IXCHEK(J)=44
C      CHAR(KK)=CHAR(KK)+CHARMO(J)
C      LINPER(KK)=LINENO(J)
C      TS(KK)=599.
C      GO TO 4222
C
C      ASSIGN THE FLAG VALUE, ASSIGN A VALUE TO TS REPRESENTING SLOW
C      SPEED TELEPRINTER TERMINALS, CHECK TO SEE IF THE LINE TYPE
C      IS FTS OR DDD, AND CHECK FOR CONTENTION.

```

PER00470
 PER00480
 PER00490
 PER00500
 PER00510
 PER00520
 PER00530
 PER00540
 PER00550
 PER00560
 PER00570
 PER00580
 PER00590
 PER00600
 PER00610
 PER00620
 PER00630
 PER00640
 PER00650
 PER00660
 PER00670
 PER00680
 PER00690
 PER00700
 PER00710
 PER00720
 PER00730
 PER00740
 PER00750
 PER00760
 PER00770
 PER00780
 PER00790
 PER00800
 PER00810
 PER00820
 PER00830
 PER00840
 PER00850
 PER00860
 PER00870
 PER00880
 PER00890
 PER00900
 PER00910
 PER00920

VIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

```

C 4001      IXCHEK(J)=44
            TS(KK)=5.
            IF (L(J).GT.2) GO TO 4006
            IF (CONTEN(J).NE.FIX) GO TO 4005

C          INCREMENT THE CONTENTION VARIABLE AND ASSIGN X THE VALUE FOR
C          CHARACTERS PER MONTH IN CONTENTION.
C          LL=LL+1
C          X(LL)=CHARMO(J)
C          GO TO 4222

C          FOR FTS AND DDD LINES, SUM THE CHARACTERS IN THE SUB-NETWORK.
C          CHAR(KK)=CHAR(KK)+CHARMO(J)
C          LINPER(KK)=LINENO(J)
C          GO TO 4222

C          FOR THOSE TERMINALS WHICH ARE FREQUENCY DIVISION MULTIPLEXED AND
C          NCT IN CONTENTION, OUTPUT THE NUMBER OF CHARACTERS ON THE
C          CHANNEL.
C          WRITE (7,101) KK,LINENO(J),CHARMO(J)
C          LINPER(KK)=LINENO(J)
C          CONTINUE
C          IF (LL.EQ.0) GO TO 4002

C          FOR THOSE TERMINALS IN CONTENTION ON THE LINE, ARRANGE THEM
C          IN DESCENDING ORDER BY NUMBER OF CHARACTERS.
C          DO 4444 II=1,LL
C          DO 4555 JJ=II,LL
C          IF (X(JJ).LT.X(II)) GO TO 4555
C          A=X(JJ)
C          X(JJ)=X(II)
C          X(II)=A
C          CONTINUE
C          LL2=LL/2

C          PAIR THE CONTENTION TERMINALS SUCH THAT THE ONE WITH THE LARGEST
C          NUMBER OF CHARACTERS IS MATED WITH THE TERMINAL WITH THE LOWEST
C          NUMBER, ETC.
C          DO 4777 II=1,LL2
C          TS(KK)=5.

```

PER00930
 PER00940
 PER00950
 PER00960
 PER00970
 PER00980
 PER00990
 PER01000
 PER01010
 PER01020
 PER01030
 PER01040
 PER01050
 PER01060
 PER01070
 PER01080
 PER01090
 PER01100
 PER01110
 PER01120
 PER01130
 PER01140
 PER01150
 PER01160
 PER01170
 PER01180
 PER01190
 PER01200
 PER01210
 PER01220
 PER01230
 PER01240
 PER01250
 PER01260
 PER01270
 PER01280
 PER01290
 PER01300
 PER01310
 PER01320
 PER01330
 PER01340
 PER01350
 PER01360
 PER01370
 PER01380

VIIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

PER01390
PER01400
PER01410
PER01420
PER01430
PER01440
PER01450
PER01460
PER01470
PER01480
PER01490
PER01500

```

4777 CHAR(KK)=CHAR(KK)+X(II)+X(LL-II+1)
4002 LINPER(KK)=LINENO(I)
4111 IF (II.LT.LL2) KK=KK+1
101 CONTINUE
      IXCHECK(I)=44
      CONTINUE
      FCRMAT (I2,I3,F10.2)
      CALL QUEUE (TS,KK,CHAR,LINPER,LINQUE,SIGMA,XLAM,YLAM,WKHSR,
102 1WLAM,ZLAM,XSIG,YSIG,NFDX)
      FCRMAT (//, K-CHAR/MO,/)
      RETURN
      END

```

QUE00010
QUE00020
QUE00030
QUE00040
QUE00050
QUE00060
QUE00070
QUE00080
QUE00090
QUE00100
QUE00110
QUE00120
QUE00130
QUE00140
QUE00150
QUE00160
QUE00170
QUE00180
QUE00190
QUE00200
QUE00210
QUE00220
QUE00230
QUE00240
QUE00250
QUE00260
QUE00270
QUE00280
QUE00290
QUE00300
QUE00310

```

      SLBROUTINE QUEUE (TS,KK,CHAR,LINPER,LINQUE,SIGMA,XLAM,YLAM,
1WKHSR,WLAM,ZLAM,XSIG,YSIG,NFDX)
      DIMENSION TS(30),RHO(30),CHAR(30),EN(30),EW(30),EQ(30),ETW(30),
      LETC(30),LINPER(30),LINQUE(30)
      DATA RHO/30*0./,EN/30*0./,EW/30*0./,EQ/30*0./,ETW/30*0./,
      LETC/30*0./
      DETERMINE THE MEAN SERVICE TIME FOR THE FRAME.
      X=XLAM/300.
      DETERMINE THE MEAN SERVICE TIME FOR TYPED IN CHARACTERS.
      Y=YLAM/300.
      DETERMINE THE MEAN SERVICE TIME FOR TELEPRINTERS.
      W=(XLAM+YLAM)/30. + YLAM/ZLAM + WLAM
      DETERMINE THE MEAN SERVICE TIME FOR CRT'S IN THE DDD OR FTS
      NETWORK.
      Z=(XLAM+YLAM)/300. + YLAM/ZLAM + WLAM
      IF HALF DUPLEX LINES ARE UTILIZED, INFORMATION CAN ONLY PASS
      IN ONE DIRECTION ON THE LINE. THE CHARACTERS TYPED IN ARE
      COMBINED WITH THE FRAMES FROM THE CPU TO DETERMINE LINE USE.
      THIS ALSO INCREASES TURNAROUND TIME AS THE LINE CHANGES FROM
      ONE DIRECTION TO ANOTHER. FOR FULL DUPLEX LINES, INFORMATION
      CAN BE TRAVELLING IN BOTH DIRECTIONS AT ONE TIME.

```



```

DO 5222 NTWO=1,2
  IF (NFDX.EQ.0.AND.NTWO.EQ.2) GO TO 5222
  WRITE (6,999)
  WRITE (7,102)
  FCRMAT ('SAVE')
  FORMAT (1X,LINE',1X,'K-CHAR',3X,'SERVICE',4X,'ARRIVAL',
2X,'UTILIZATION',2X,'TRANS.',4X,'TRANS. IN',3X,'TIME IN',
1 2X/2X,'NO.',1X,'/MONTH',4X,'TIME',7X,'RATE',16X,'WAITING',
1 5X,'SYSTEM',5X,'SYSTEM/')
  DO 5111 I=1,KK
    C=CHAR(I)
    IF (TS(I).EQ.5.) GO TO 5005
    IF (NTWO.EQ.1) GO TO 5006
    TTT=Y
    SIGMA=YSIG/300.
    GO TO 5007
  TTT=X
  IF (NFDX.EQ.0) TTT=X+Y
  SIGMA=XSIG/300.
  IF (NFDX.EQ.0) SIGMA=(SQRT(XSIG**2.+YSIG**2.))/300.
  GO TO 5007
5006
  TTT=W
  SIGMA=SQRT((XSIG**2.+YSIG**2.)/(30.))*2.+(YSIG/ZLAM)**2.)
  IF (LINPER(I).GE.10) GO TO 5020
  IF (TTT.EQ.W) GO TO 5021
  TTT=Z
  SIGMA=SQRT((XSIG**2.+YSIG**2.)/(300.))*2.+(YSIG/ZLAM)**2.)
  IF (LINQUE(I).EQ.0) GO TO 5020
  C=C/LINQUE(I)
5005
5007
5021
  DETERMINE THE MEAN ARRIVAL RATE OF TRANSACTIONS ON THE LINE.
  EN(I)=1000.*C/((XLAM+YLAM)*WKHRS*3600.)
5020
  DETERMINE THE LINE UTILIZATION.
  RHO(I)=EN(I)*TTT
  DETERMINE THE NUMBER OF TRANSACTIONS IN THE NETWORK WAITING
  FOR SERVICE.
  EW(I)=((EN(I)*SIGMA)**2.)+(RHO(I)**2.)/(2.*(1.-RHO(I)))
  DETERMINE THE TOTAL NUMBER OF TRANSACTIONS IN THE NETWORK,
  BEING SERVED OR WAITING TO BE SERVED.

```


VIIIS COST AND PERFORMANCE PROGRAM LISTING

CONTINUED

```

EQ(I)=EW(I)+RHO(I)
C
C DETERMINE THE MEAN WAITING TIME FOR SERVICE.
C
    IF (C.EQ.0.) GO TO 5001
    ETW(I)=EW(I)/EN(I)
    GO TO 5002
    ETW(I)=0.
5001
C DETERMINE THE TOTAL TIME IN THE SYSTEM, WAITING TO BE SERVED
C AND BEING SERVED.
C
    ETQ(I)=ETW(I)+TTT
C
C OUTPUT THE TOTAL CHARACTERS ON THE LINE, THE LINE NUMBER, THE
C MEAN SERVICE RATE, THE UTILIZATION, THE MEAN NUMBER OF
C TRANSACTIONS WAITING FOR SERVICE, THE TOTAL NUMBER OF TRANSACTIONS
C IN THE SYSTEM, THE WAIT TIME FOR SERVICE, AND THE MEAN TOTAL TIME
C IN THE SYSTEM.
C
    WRITE (7,101) I,LINPER(I),C,TTT,EN(I),RHO(I),EW(I),
    EQ(I),ETQ(I)
    CONTINUE
5111
5222 CCNTINUE
101  FORMAT (I2,I3,F8.0,6(2X,E9.3))
    RETURN
    END

```

QUE00760
 QUE00790
 QUE00800
 QUE00810
 QUE00820
 QUE00830
 QUE00840
 QUE00850
 QUE00860
 QUE00870
 QUE00880
 QUE00890
 QUE00900
 QUE00910
 QUE00920
 QUE00930
 QUE00940
 QUE00950
 QUE00960
 QUE00970
 QUE00980
 QUE00990
 QUE01000
 QUE01010
 QUE01020
 QUE01030
 QUE01040

APPENDIX G
VIIS - SAMPLE INPUT96

VIIIS - SAMPLE INPUT

INPUT MEAN CHARACTERS TYPED-IN PER TRANSACTION
300.
INPUT THE STANDARD DEVIATION
100.
INPUT THE MEAN TYPING SPEED IN CHARACTERS PER SECOND
3.
INPUT THE MEAN ACCESS TIME PER TRANSACTION
1.0
INPUT THE NUMBER OF WORKING HOURS PER MONTH
168.
INPUT 0 FOR HALF DUPLEX LINES
1

22 EQUIPMENT COSTS
1850. 22. 50. 83.
2130. 25. 30. 95.
2430. 27. 30. 107.
3575. 45. 75. 170.
1975. 25. 75. 95.
480. 2. 30. 16.
0. 4.50 4.50
2138. 5. 238. 55.
5300. 15. 200. 100.
7350. 21. 250. 125.
9600. 28. 300. 230.
570. 2. 70. 12.
625. 2. 0. 38.
70. 0. 4. 0.
1700. 5. 100. 52.
350. 1. 0. 11.
300. 1. 0. 10.
0. 49. 0. 49.
0. 42. 0. 42.
0. 16. 0. 16.
0. 125. 0. 125.
0. 12.50 12.50

05 LINE COSTS
0.54
0.00
8.40
66.00
0.00

APPENDIX H

VIIS - SAMPLE OUTPUT

BASELINE - MIXED TERMINAL

PURCHASED EQUIPMENT

CRT	12	CATHODE RAY TUBE DISPLAY TERMINAL
TPTR	15	TELEPRINTER
TPTR/C	34	TELEPRINTER WITH COUPLER
PTR	7	HIGH SPEED PRINTER
HDCPY	3	SLOW SPEED PRINTER
FDMCSS	39	FDM CHASSIS
DAA	33	DATA ACCESS ARRANGEMENT
S2400M	15	SYNCHRONOUS 2400 BIT PER SECOND MODEM
S4800M	0	SYNCHRONOUS 4800 BIT PER SECOND MODEM
S7200M	4	SYNCHRONOUS 7200 BIT PER SECOND MODEM
S9600M	4	SYNCHRONOUS 9600 BIT PER SECOND MODEM
A3CCM	23	ASYNCHRONOUS 300 BIT PER SECOND MODEM
MSD	1	MODEM SHARING DEVICE
ADD	10	ALTERNATE DIAL-UP DEVICE
TDMCSS	4	TDM CHASSIS
FDMCNL	61	FDM CHANNEL
TDMCNL	28	TDM CHANNEL
C2CCND	4	C2 LINE CONDITIONING
GSATER	53	GSA LINE TERMINATIONS
LCLTEL	0	LOCAL TELEPHONE LINE

VIIS - SAMPLE OUTPUT

FTSNTC	4	FTS NIGHT CIRCUIT						
FTSEXT	5	FTS EXTENSION						
			VIIS ONE-TIME	VIIS MONTHLY	VIIS LINE-COST	SHARED ONE-TIME	SHARED MONTHLY	SHARED LINE-COST
	1		31561.00	562.50	319.14	14700.00	175.00	0.0
	2		25400.00	512.00	417.56	26800.00	213.00	0.0
	3		40091.00	801.50	606.42	14700.00	175.00	0.0
	4		40259.00	655.00	476.28	26800.00	213.00	0.0
	5		25050.00	511.00	497.34	0.0	0.0	0.0
	6		46874.00	681.00	1460.16	0.0	0.0	0.0
			FTS CON ONE-TIME	FTS CON MONTHLY	FTS CON LINE-COST	FTS NCON ONE-TIME	FTS NCON MONTHLY	FTS NCON LINE-COST
			13080.00	152.00	485.70	13500.00	220.00	4345.11
			DDD ONE-TIME	DDD MONTHLY	DDD LINE-COST			
			18480.00	215.00	0.0			
DTOT	=		6995.00	TOTAL LEASED-DEDICATED MILEAGE				
DTOT2	=		2034.64	TOTAL LEASED-SHARED MILEAGE				
TCOST	=		337295.00	TOTAL ONE-TIME COSTS				
TCOSTM	=		13694.03	TOTAL MONTHLY RECURRING COSTS				
DLUSTO	=		3290.12	TOTAL CONNECT HOURS				

VIIS - SAMPLE OUTPUT				CONTINUED		
NODE	DESIG LINE NC.	MILAGE	CONNECT HOURS	EQUIPMENT COST RECURRING	ONE-TIME	LINE COST
WACC	VIS 111	0.0	0.0	45.00	2230.00	0.0
WACC	VIS 212	0.0	0.0	63.00	7350.00	0.0
WACC	VIS 221	0.0	0.0	82.00	13400.00	0.0
WACC	VIS 231	0.0	0.0	50.00	2580.00	0.0
WACC	VIS 232	0.0	0.0	63.00	7350.00	0.0
WACC	VIS 242	0.0	0.0	82.00	13400.00	0.0
WACC	VIS 151	0.0	0.0	49.00	2230.00	0.0
WACC	VIS 3 1	FTS-CONUS	0.0	26.00	2280.00	0.0
WACC	VIS 5 5	0.0	0.0	26.00	2280.00	0.0
BAMC	WACC 111	36.00	81.92	72.00	3260.00	19.44
PHPA	BAMD 111	90.00	78.42	72.00	3260.00	48.60
NYNY	PHPA 111	90.00	43.77	72.00	3260.00	48.60
NYNY	WACC 212	205.42	0.0	112.00	7350.00	0.0
NYNY	WACC 112	0.0	0.0	5.00	2138.00	0.0
NYNY	NYNY 112	0.0	137.66	76.50	7633.00	0.0
ALNY	WACC 3 1	FTS-CONUS	12.26	31.50	2700.00	102.95
PRRI	NYNY 111	234.00	17.97	72.00	3260.00	126.36
BOMA	PRRI 111	42.00	48.19	72.00	3260.00	22.68
POME	BCMA 111	99.00	54.98	72.00	3260.00	53.46
SLMC	WACC 221	707.84	0.0	115.00	9600.00	0.0
SLMC	SLMC 161	0.0	0.0	47.00	2138.00	0.0
SLMC	SLMC 221	0.0	0.0	12.00	3800.00	0.0
SLMC	SLMC 221	0.0	0.0	50.00	2580.00	0.0
PAKY	SLMC 121	0.0	74.26	30.00	3260.00	0.0
MEIN	PAKY 121	136.00	38.54	72.00	3260.00	73.44
NATN	MEIN 121	155.00	63.51	72.00	3260.00	83.70
LOKY	NATN 121	120.00	17.97	72.00	3260.00	64.80
CICH	LCKY 121	153.00	15.78	72.00	3260.00	82.62
HUVV	CIOH 121	89.00	26.94	72.00	3260.00	48.06
YOVA	WACC 121	121.00	79.51	72.00	3260.00	65.34
YOVA	NOVA 131	131.00	0.0	98.50	3260.00	70.74
NOVA	WACC 132	27.00	81.31	112.00	6033.00	14.58
NOVA	WACC 232	157.11	0.0	47.00	7350.00	0.0
NOVA	NCVA 132	0.0	0.0	72.00	2138.00	0.0
NOVA	YCVA DC5	27.00	43.77	30.00	3260.00	14.58
NOVA	NCVA 131	0.0	86.73	72.00	3260.00	0.0
WINC	NCVA 131	204.00	31.54	72.00	3260.00	110.16
CHSC	WINC 131	152.00	18.84	72.00	3260.00	82.08
SAGA	CHSC 131	83.00	17.97	72.00	3260.00	44.82
JAFI	SAGA 131	125.00	50.60	72.00	3260.00	67.50
TAFI	JAFI 131	171.00	48.41	72.00	3260.00	92.34
MIFL	TAFI 131	203.00	70.30	72.00	3260.00	109.62
NOLA	WACC D08	964.28	0.0	98.00	2100.00	0.0

VIIS - SAMPLE OUTPUT

CONTINUED

Address	Op	Op1	Op2	Op3	Op4	Op5	Op6	Op7	Op8	Op9	Op10	Op11	Op12	Op13	Op14	Op15	Op16	Op17	Op18	Op19	Op20	Op21	Op22	Op23	Op24	Op25	Op26	Op27	Op28	Op29	Op30	Op31	Op32	Op33	Op34	Op35	Op36	Op37	Op38	Op39	Op40	Op41	Op42	Op43	Op44	Op45	Op46	Op47	Op48	Op49	Op50	Op51	Op52	Op53	Op54	Op55	Op56	Op57	Op58	Op59	Op60	Op61	Op62	Op63	Op64	Op65	Op66	Op67	Op68	Op69	Op70	Op71	Op72	Op73	Op74	Op75	Op76	Op77	Op78	Op79	Op80	Op81	Op82	Op83	Op84	Op85	Op86	Op87	Op88	Op89	Op90	Op91	Op92	Op93	Op94	Op95	Op96	Op97	Op98	Op99	Op100	Op101	Op102	Op103	Op104	Op105	Op106	Op107	Op108	Op109	Op110	Op111	Op112	Op113	Op114	Op115	Op116	Op117	Op118	Op119	Op120	Op121	Op122	Op123	Op124	Op125	Op126	Op127	Op128	Op129	Op130	Op131	Op132	Op133	Op134	Op135	Op136	Op137	Op138	Op139	Op140	Op141	Op142	Op143	Op144	Op145	Op146	Op147	Op148	Op149	Op150	Op151	Op152	Op153	Op154	Op155	Op156	Op157	Op158	Op159	Op160	Op161	Op162	Op163	Op164	Op165	Op166	Op167	Op168	Op169	Op170	Op171	Op172	Op173	Op174	Op175	Op176	Op177	Op178	Op179	Op180	Op181	Op182	Op183	Op184	Op185	Op186	Op187	Op188	Op189	Op190	Op191	Op192	Op193	Op194	Op195	Op196	Op197	Op198	Op199	Op200	Op201	Op202	Op203	Op204	Op205	Op206	Op207	Op208	Op209	Op210	Op211	Op212	Op213	Op214	Op215	Op216	Op217	Op218	Op219	Op220	Op221	Op222	Op223	Op224	Op225	Op226	Op227	Op228	Op229	Op230	Op231	Op232	Op233	Op234	Op235	Op236	Op237	Op238	Op239	Op240	Op241	Op242	Op243	Op244	Op245	Op246	Op247	Op248	Op249	Op250	Op251	Op252	Op253	Op254	Op255	Op256	Op257	Op258	Op259	Op260	Op261	Op262	Op263	Op264	Op265	Op266	Op267	Op268	Op269	Op270	Op271	Op272	Op273	Op274	Op275	Op276	Op277	Op278	Op279	Op280	Op281	Op282	Op283	Op284	Op285	Op286	Op287	Op288	Op289	Op290	Op291	Op292	Op293	Op294	Op295	Op296	Op297	Op298	Op299	Op300	Op301	Op302	Op303	Op304	Op305	Op306	Op307	Op308	Op309	Op310	Op311	Op312	Op313	Op314	Op315	Op316	Op317	Op318	Op319	Op320	Op321	Op322	Op323	Op324	Op325	Op326	Op327	Op328	Op329	Op330	Op331	Op332	Op333	Op334	Op335	Op336	Op337	Op338	Op339	Op340	Op341	Op342	Op343	Op344	Op345	Op346	Op347	Op348	Op349	Op350	Op351	Op352	Op353	Op354	Op355	Op356	Op357	Op358	Op359	Op360	Op361	Op362	Op363	Op364	Op365	Op366	Op367	Op368	Op369	Op370	Op371	Op372	Op373	Op374	Op375	Op376	Op377	Op378	Op379	Op380	Op381	Op382	Op383	Op384	Op385	Op386	Op387	Op388	Op389	Op390	Op391	Op392	Op393	Op394	Op395	Op396	Op397	Op398	Op399	Op400	Op401	Op402	Op403	Op404	Op405	Op406	Op407	Op408	Op409	Op410	Op411	Op412	Op413	Op414	Op415	Op416	Op417	Op418
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K-CHAR/MO

1	3743.00
1	3583.00
1	2202.00
1	2512.00
4	3539.00

LINE NC.	K-CHAR /MCNTH	SERVICE TIME	ARRIVAL RATE	UTILIZATION	TRANS. WAITING	TRANS. IN SYSTEM	TIME IN SYSTEM
4 21	1761.00	0.173E 03	0.212E-02	0.367E 00	0.111E 00	0.479E 00	0.226E 03
4 21	2502.00	0.633E 01	0.763E-02	0.484E-01	0.128E-02	0.496E-01	0.650E 01
4 21	1231.00	0.173E 03	0.209E-02	0.361E 00	0.107E 00	0.468E 00	0.225E 03
4 21	3633.00	0.173E 03	0.116E-02	0.201E 00	0.263E-01	0.227E 00	0.196E 03
5 31	3963.00	0.173E 03	0.241E-02	0.418E 00	0.157E 00	0.575E 00	0.238E 03
10 41	2000.00	0.173E 03	0.235E-02	0.408E 00	0.147E 00	0.555E 00	0.236E 03
10 41	3262.00	0.173E 03	0.231E-02	0.400E 00	0.139E 00	0.540E 00	0.234E 03
10 41	3232.00	0.173E 03	0.259E-02	0.448E 00	0.190E 00	0.638E 00	0.247E 03
10 41	3322.00	0.633E 01	0.451E-02	0.286E-01	0.438E-03	0.290E-01	0.643E 01
10 41	1561.00	0.173E 03	0.0	0.0	0.0	0.0	0.173E 03
12 51	3132.00	0.633E 01	0.318E-01	0.201E 00	0.265E-01	0.228E 00	0.717E 01
12 51	2000.00	0.173E 03	0.123E-02	0.214E 00	0.303E-01	0.244E 00	0.198E 03
12 51	3703.00	0.173E 03	0.117E-02	0.202E 00	0.267E-01	0.229E 00	0.196E 03
14 61	24987.	0.633E 01	0.188E-01	0.119E 00	0.838E-02	0.127E 00	0.678E 01
15 5	4000.	0.173E 03	0.301E-02	0.521E 00	0.296E 00	0.817E 00	0.272E 03

VIIS - SAMPLE OUTPUT							CONTINUED	
LINE NC.	K-CHAR /MCNTH	SERVICE TIME	ARRIVAL RATE	UTILIZATION	TRANS. WAITING	TRANS. IN SYSTEM	TIME IN SYSTEM	
1 11	2821.	0.173E 03	0.212E-02	0.367E 00	0.111E 00	0.479E 00	0.226E 03	
2 12	10158.	0.100E 01	0.763E-02	0.763E-02	0.326E-04	0.767E-02	0.100E 01	
3 1	2775.	0.173E 03	0.209E-02	0.361E 00	0.107E 00	0.468E 00	0.225E 03	
4 21	1542.	0.173E 03	0.116E-02	0.201E 00	0.263E-01	0.227E 00	0.196E 03	
5 31	3212.	0.173E 03	0.241E-02	0.418E 00	0.157E 00	0.575E 00	0.238E 03	
6 31	3133.	0.173E 03	0.235E-02	0.408E 00	0.147E 00	0.555E 00	0.236E 03	
7 31	3073.	0.173E 03	0.231E-02	0.400E 00	0.139E 00	0.540E 00	0.234E 03	
8 31	3441.	0.173E 03	0.259E-02	0.448E 00	0.150E 00	0.638E 00	0.247E 03	
9 32	6000.	0.100E 01	0.451E-02	0.451E-02	0.113E-04	0.452E-02	0.100E 01	
10 41	0.	0.173E 03	0.0	0.0	0.0	0.0	0.173E 03	
11 42	42322.	0.100E 01	0.318E-01	0.318E-01	0.581E-03	0.324E-01	0.102E 01	
12 51	1641.	0.173E 03	0.123E-02	0.214E 00	0.303E-01	0.244E 00	0.198E 03	
13 51	1552.	0.173E 03	0.117E-02	0.202E 00	0.267E-01	0.229E 00	0.196E 03	
14 61	24987.	0.100E 01	0.188E-01	0.188E-01	0.200E-03	0.190E-01	0.101E 01	
15 5	4000.	0.173E 03	0.301E-02	0.521E 00	0.296E 00	0.817E 00	0.272E 03	

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